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Problems in Helicopter Gunnery

by

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The research was designed to determine (a) whether targets can be identified by air crewmen at ranges in excess of 3000 meters, and (b) whether current training meets the needs for long range target identification. Reduced-scale tachniques were employed.

Helicopter crewmen could recognize and identify the armored vehicles at scaled ranges of 3000 and 4000 meters. All of the crewmen who served as → over

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Observers in the experiments were able to learn to identify the armored vehicles almost 100% correctly. Target view was the only factor significantly related to recognition and identification performance. Differences in performance at the two ranges (3000 and 4000 meters) were not statistically significant. Likewise, differences in performance for the five different target vehicles were not statistically significant.

Relatively brief training markedly improved observer performance.

FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity; formerly called MASSTER--Modern Army Selected Systems Test Evaluation and Review). This support is provided by assessing human performance aspects in field evaluations of man/weapons systems.

This report presents the results of experimental studies designed to determine whether attack helicopter crewmen can identify armored vehicles at the standoff ranges (3000 to 4000 meters) made necessary by modern battlefield conditions. The studies also explore training methods by which the capabilities of helicopter crewmen to identify armored vehicles at long ranges may be raised to near 100 percent accuracy.

ARI research in this area is conducted as an in-house effort, and as joint efforts with organizations possessing unique capabilities for human factors research. The research described in this report was done by personnel of the Human Resources Research Organization (HumRRO), under contract DAHC19-75-C-0025, monitored by personnel from the ARI Fort Hood Field Unit. This research is responsive to the special requirements of TCATA, the 6th US Cavalry Brigade (Air Combat), and the objectives of RDTE Project 2Q763743A775, "Human Performance in Field Assessment," FY 77 Work Program.

PROBLEMS IN HELICOPTER GUNNERY

BRIEF

Requirement:

The work of this study is that originally referred to in paragraph 2.2.3 of the Statement of Work dated 3 February 1977 (revised), under the title, "Pilot and Aircrew Workload Assessment." The title of this report was changed to more accurately reflect the actual requirements contained in the Human Resources Need (HRN) statements submitted by the 6th US Cavalry Brigade (Air Combat), Fort Hood, Texas. Brigade authorities were primarily concerned with target identification by attack helicopter crewmen. The Brigade was concerned about the adequacy of the current training program for developing the capability to identify targets at long ranges. Guided further by conversations with personnel of the 6th US Cavalry Brigade (Air Combat), the following objectives were developed for this study:

- To determine whether helicopter crewmen, who had received previous training in armored vehicle identification, could recognize and identify armored vehicles at the standoff ranges (3000 to 4000 meters) made necessary by modern battlefield conditions. (Recognition was defined as labeling a vehicle as friendly or threat. Identification meant specifically labeling a vehicle as an M60, T54, Chieftain, etc.)
- To determine whether helicopter crewmen could be trained to identify armored vehicles at standoff ranges with near-perfect accuracy.

Procedure:

Scale model armored vehicles were presented to observers at scaled ranges calculated to simulate full-scale ranges of 3000 and 4000 meters. Two experiments were designed and carried out, the first one being a preliminary, exploratory experiment, and the second one a larger experiment designed on the basis of lessons learned from the preliminary experiment. The observers used optical aids to view the scale model armored vehicles; 7x50 binoculars were used in the preliminary experiment, and the XM65 gunsight in an attack helicopter in the main experiment.

The experiments were designed and analyzed so that they provided information on the pretraining recognition and identification capabilities of the observers, their performance during training, and their posttraining recognition and identification capabilities. Scale models of five different armored vehicles (M60 tank, M113 Armored Personnel Carrier, Chieftain tank, T54 tank, and ZSU 57/2 Air Defense System) were used throughout the experiments. Two additional vehicles (AMX 30 tank and PT 76 Armored Reconnaissance Vehicle) were introduced during the

posttraining phase of the experiments to test the reactions of the observers to unfamiliar vehicles. The scale model armored vehicles were presented in five different views -- side left, oblique left, front, oblique right, and side right.

Principal Findings:

- Helicopter crewmen could recognize and identify the armored vehicles at scaled ranges of 3000 and 4000 meters. Pretraining recognition performance averaged from 76 percent to 96 percent correct for the five armored vehicles, while pretraining identification performance averaged from 48 percent to 77 percent correct for the five vehicles under the relatively ideal viewing conditions of these experiments.
- All of the helicopter crewmen who served as observers in these experiments were able to learn to recognize and identify the armored vehicles to a level of almost 100 percent correct.
- Target view was found to be the only factor significantly related to recognition and identification performance. Differences in recognition and identification performance at the two different ranges (3000 and 4000 meters) were not statistically significant. Likewise, differences in recognition and identification performance for the five target vehicles were not statistically significant.

Utilization of Findings:

Attack helicopter crewmen <u>can</u> identify armored vehicle targets at standoff ranges, using the XM65 gunsight (13X) under the relatively ideal viewing conditions of these experiments. However, their pretraining identification performance can be sharply improved by relatively brief training of the kind used in these experiments. Further research is planned to explore the effect of less than ideal viewing conditions on target recognition capability. However, operational units can begin immediately to develop training programs of the kind used in these studies.

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CHAPTER 1

INTRODUCTION

The basis for the research described in this report was three Human Resources Need (HRN) statements submitted by the 6th US Cavalry Brigade (Air Combat). The subjects discussed in these three statements were:

1. Long range target identification for attack helicopter crewmen.

2. The effectiveness of simulated fire versus live fire training for helicopter gunnery.

3. Fatigue effects in CAV NAV (AN/PVS-5) goggle use.

The problems that gave rise to these HRN statements should be common to all aviation units with similar missions.

In conversations with personnel of the 6th US Cavalry Brigade (Air Combat), it was indicated that work in the target identification area should be given priority. The work on simulation versus live firing in helicopter gunnery was planned as part of a TCATA test, since such work is extremely costly. The TCATA test has been delayed and finally cancelled, so nothing more than preliminary planning was accomplished in this area. Some preliminary exploration of problems in the use of the CAV NAV (AN/PVS-5) goggles has been done and is described later in this report. Work in the related area of target handoff techniques involving attack helicopters is being reported separately.

Military Problem

The threat armored forces likely to be engaged by US and other NATO units in a mid- to high-intensity conflict in Europe are equipped with antitank missile systems that are both accurate and lethal out to about

3000 meters. Further, these forces employ sophisticated air defense systems in the forward areas of a battle zone that are effective collectively between ranges of 2500 to 10,000 meters (depending on such target parameters as speed, altitude, and heading). In addition, threat forces likely to be engaged in central Europe are quite large, particularly the armored forces. In fact, it has been estimated that US units in a central European conflict can expect to face situations in which the force ratio may be as high as six to one (6:1). As a consequence, US military planners, in defining the role of aeroscout/attack helicopter teams have determined that Attack Helicopters (AHs) equipped with the TOW weapon system will generally fly and fight using Nap-of-the-Earth (NOE) tactics and will engage designated targets, to the extent possible, at standoff ranges (i.e., beyond 3000 meters). Flying NOE and firing the TOW at standoff ranges will make AHs far less vulnerable to enemy forward area air defense systems than they would be at the ranges required for engaging with 2.75 rockets or conventional tube-type weapons.

However, there is a potential problem with these tactics. Can helicopter crewmen identify targets at these ranges? Before attacking, the AH crew must make a positive visual identification of potential targets, according to current doctrine. At standoff ranges both friendly and threat armored vehicles present very small visual images, about three to four minutes of visual angle, when viewed by the unaided eye. Even with optical aids (such as 7x50 binoculars or the 13 power XM65 COBRA-TOW gunsight), these images are still so small that only gross target features are clearly recognizable. A further complicating factor in this situation is that friendly and threat armored vehicles are very

similar in terms of shape, overall physical dimensions, and locations of external items, such as machineguns. When all of the factors are considered, it is likely that the accurate discrimination of one type of armored vehicle from another may be quite difficult at standoff ranges.

In view of all these factors, concern was expressed by personnel of the 6th US Cavalry Brigade (Air Combat) as to whether armored vehicles could be reliably recognized at these ranges, even with the 13X gunsight. As a corollary of this concern, questions about the effectiveness of current recognition/identification training programs for target identification at these ranges were also raised. In response to these concerns, the studies described in this report were planned to determine whether reliable target identification was possible at ranges beyond 3000 meters and if so, whether the current training conducted by the 6th US Cavalry Brigade (Air Combat) was adequate for this task.

During the early stages of the work it was realized that a major research effort was required to examine the effects of such factors as camouflage, partial obscuration, noise, vibration, atmospheric degradation, illumination level, and background. Such a major research effort was clearly beyond the scope of the present work. Therefore, it was recommended that a separate research program be established to attack this problem in more detail. However, to obtain preliminary information on the extent of the problem so that some immediate guidance could be given to the 6th US Cavalry Brigade (Air Combat), the studies described in this report were undertaken.

Research Problem and Approach

Recognition and Identification. The perception of objects in the real world may be characterized as proceeding from detection, "There's something out there!"; to recognition, "It's a tank!"; to identification, "It's an M60!" Target detection is sometimes difficult, but in this study this problem is not dealt with. The focus in this study is on the areas of recognition and detection.

Recognition is generally defined as placing the perceived object in some class; for example, recognizing that the approaching vehicle is an automobile, rather than a truck or an airplane. Identification is defined as a more specific labeling of the object; for example, specifying that the approaching automobile is a Model A Ford, rather than a Model T or a more recent model.

The most important general classification that may be made of a vehicle seen on a battlefield is whether it is a friend or a threat. Therefore, in this research recognition is defined as labeling an armored vehicle as friend or threat. Identification is defined as specifically labeling the armored vehicle as an M60, a Chieftain, a T54, or whatever.

Experimental Conditions. The requirements which this research has attempted to satisfy, and the constraints under which it has been carried out, have together determined the experimental conditions employed. The intial requirement for this research was quite general and indicated that the study should investigate the capabilities of helicopter crew personnel to accurately identify armored vehicles at standoff ranges both with and without optical aids. However, from discussions with the 6th Cavalry Brigade personnel, it was learned that their immediate

interest was in the ability of AH crewmen to identify armored vehicles using the XM65 gunsight adjusted to the high magnification (13X) setting. Therefore, this research was limited to target identification using an optical aid.

An obvious method to use in determining whether observers and pilots could accurately identify armored vehicles at standoff ranges would be to have full scale models or the actual vehicles dispersed over terrain as they would be under battle conditions, and to have pilots and observers flying in helicopters at standoff ranges. While this method would have obvious field validity, it is impracticable on several counts. First, it would be extremely expensive to fly helicopters day after day for the time needed to gather enough data for reliable conclusions. Second, many of the actual vehicles one would want to use (including US, British, French, German, Italian, and Warsaw Pact armored vehicles) are simply not available, and even full scale models would be quite expensive to fabricate. Third, it would be very difficult to maintain good experimental control over a field study of this kind. Precise control of such factors as target-to-observer ranges, order of target presentation, light and shadow conditions, and angle from which the targets were viewed would be difficult, costly, and in some cases impossible to maintain.

For the reasons given above, it was decided to study the target identification problem in a reduced scale situation. Such an approach is common in studies of target detection and recognition,[1,2,3,4,5,6,7]

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[1] R. D. Baldwin, E. W. Frederickson, and E. C. Hackerson. *Aircraft Recognition Performance of Crew Chiefs with and without Forward Observers*, Technical Report 70-12, Human Resources Research Organization, Alexandria, Virginia, August 1970.

particularly when they involve targets that are expensive to operate or difficult to obtain for experimental purposes. Simulated ranges of 3000 meters and 4000 meters were chosen for use in these studies. Three thousand meters is about as close as an AH will normally approach in combat. Four thousand meters is just outside the maximum range of the TOW system as installed on AHs, and therefore is a range at which the target might be identified before moving in for the attack.

As a first step, it was decided to study the recognition and identification of armored vehicles under relatively ideal conditions to determine whether helicopter pilots and observers could identify the targets at standoff ranges. If it were found that they could identify the targets under ideal viewing conditions, it was planned that an additional research effort would be instituted to explore the effects of

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[2] R. D. Baldwin, R. E. Cliborn, and R. J. Foskett. *The Acquisition and Retention of Visual Aircraft Recognition Skills*, Final Report FR-WD(TX)-76-10, Human Resources Research Organization, Alexandria, Virginia, August 1976.

[3] H. R. Blackwell, J. Ohmart, and R. Harcum. *Field and Simulator Studies of Air-to-Ground Visibility Distances*, Report No. 2643-3-F, Ann Arbor, Michigan: University of Michigan Research Institute, December 1958.

[4] D. Gordon and G. Lee. *Model Simulations Studies - Visibility of Military Targets as Related to Illuminant Position*, Report No. 2144-341-T, Ann Arbor, Michigan: University of Michigan Research Institute, March 1959.

[5] M. R. McCluskey, A. D. Wright, and E. W. Frederickson. *Studies on Training Ground Observers to Estimate Range to Aerial Targets*, Technical Report 68-5, Human Resources Research Organization, Alexandria, Virginia, May 1968.

[6] H. Whitehurst. *The Effects of Pattern and Color on the Visual Detection of Camouflaged Vehicles*, NWC TR 5746, Naval Weapons Center, China Lake, California, March 1975.

[7] H. Whitehurst. *Effect of Camouflage Paint Patterns on the Surface Detection of Vehicles*, NWC TR 5772, Naval Weapons Center, China Lake, California, June 1975.

various degrading factors on target identification. The two studies described in this report were both done under relatively ideal viewing conditions.

The use of a reduced scale experimental situation contributes to ideal viewing conditions, in that atmospheric haze and scintillation are almost completely eliminated as degrading factors. The scaled ranges used in these studies are so short (18.57 meters to 45.98 meters) that these factors are almost completely absent. The lighting of the reduced scale target scene in these studies was relatively ideal (though the illumination levels ranged from 240 to 9767 foot-candles).

The scale model vehicles used in these studies were made of molded plastic in a dark olive drab color. They were displayed on a wooden platform (with vertical background) which was covered with papier mache and painted a medium dark forest green. This highly textured background provided moderate brightness and color contrast ratios. No elements of camouflage, terrain masking, or vegetative masking were used in the target presentation scene.

Yet another factor that is likely to cause the performance of the subjects in these two studies to be better than would be expected in the real-life field situation is the fact that only five kinds of armored vehicles were used (except for a very limited amount of testing done with two additional vehicles). Learning to identify a set of five armored vehicles is obviously easier than learning to identify the much larger set of armored vehicles that might appear on a central European battlefield.

Objectives of the Studies

The main objective of these studies has been to evaluate the capability of helicopter crew personnel who should have received some previous training in target identification to identify armored vehicles at standoff ranges. Secondary objectives have been to determine whether recognition and identification capabilities differ significantly for different kinds of vehicles; for side, oblique, and front views of the vehicles; and for the two different ranges employed. It was also desired to determine whether personnel whose initial recognition and identification capabilities were relatively poor could readily learn to recognize and identify the vehicles at a near-perfect level. Finally, it was also desired to learn something about the reactions of personnel when they were presented with unfamiliar vehicles, on which they had received no identification training.

Overview of the Report

The remainder of this report consists of a description of the two vehicle identification studies that were carried out, and of the results obtained. Chapter 2 describes the preliminary experiment and discusses the results obtained, while Chapter 3 is devoted to the larger, main experiment. The results of both studies are summarised and discussed in Chapter 4. Finally, in Chapter 5, two additional topics are briefly discussed. They are the effectiveness of simulated fire versus live-fire for training gunners for the COBRA-TOW attack helicopter system; and fatigue effects of night vision goggle (AN/PVS-5) use. These areas were included in the HRNs submitted by the 6th US Cavalry (Air Combat),

but little work has been accomplished thus far for reasons outlined in Chapter 5. Technical details of the experimental designs and analyses are then presented in a Technical Appendix.

CHAPTER 2

PRELIMINARY EXPERIMENT

The first experiment was a limited, exploratory study of the abilities of helicopter crew personnel to recognize and identify scale models of armored vehicles at scaled ranges of 3000 and 4000 meters.

DESCRIPTION OF THE EXPERIMENT

Method

This experiment involved a training phase and a testing phase. In the training phase, scale models of five different armored vehicles were used. Each of these vehicles was presented in three different views (side, oblique, and front) to each observer. Thus, a series of 15 presentations was used at a scaled range of 3000 meters, and another series of 15 presentations was used at a scaled range of 4000 meters. Half the observers were given one series of 15 presentations at 3000 meters first, and then the other series at 4000 meters. The other half of the observers were presented targets at 4000 meters first, and then at 3000 meters. A table showing the order in which each observer viewed targets at each scaled range during both the training and testing phases of the experiment is given in Technical Appendix A.

Each observer was asked to indicate whether the vehicle was a friendly or a threat vehicle, and then to name (identify) the vehicle. During the training phase, the observer was told after responding to each presentation whether his responses were correct, and if either was incorrect, he was given the correct information.

In the testing phase, seven vehicles were used; the five used in the training phase plus two additional, unfamiliar vehicles. Each of

the seven vehicles was presented in the three views; thus, a series of 21 presentations was made to each observer at a scaled range of 3000 meters and another series of 21 presentations was made at 4000 meters. As in the training phase, the order of the presentations at 3000 and 4000 meters was counterbalanced. Again the observers were asked to label each vehicle as friendly or threat, and then to identify it. However, in the testing phase, the observers were not told whether their responses were correct.

During the training series, the first response made to each of the five vehicles was used to estimate the initial recognition and identification capabilities of the observers. Data from all of the responses on both the training series and the testing series were used to determine whether the two different ranges and the five types of armored vehicles made any differences in the level of recognition and identification performance. Data obtained from the responses on the testing series were analyzed for the effects of target view (side, oblique, or front) on recognition and identification performance. Data were obtained on the subjects' reactions to unfamiliar vehicles from the responses to the two additional vehicles used in the testing series. No training on these two vehicles had been given in this experiment.

Observers

The observers for this experiment were 10 enlisted and 10 officer personnel from the 4/9 Cavalry, 6th US Cavalry Brigade (Air Combat), Fort Hood, Texas. Seventeen of these observers had 20/20 visual acuity or better, one had an acuity of 20/25, while the other two had acuities of 20/30. Since differences in visual acuity can normally be corrected

by properly focusing the binoculars used in this experiment (unless astigmatism is present), these cases of less than normal visual acuity are not considered likely to have hindered recognition and identification performance.

Seventeen of the 20 observers had received formal training in target identification. Eight of the 10 enlisted observers had completed a formal course of instruction in target identification and were classified as aerial scout observers (MOS 11D2F). Nine of the 10 officer observers had received training in vehicle identification while in helicopter flight school. Of the three observers who had received no formal instruction in target identification, two were REDEYE gunners (MOS 16P10) assigned to the 4/9 Headquarters Troop, while the remaining observer was a 1LT recently assigned to the 4/9 Cavalry.

Simulation of the Environment

Scale model armored vehicles were presented to the observers in a reduced-scale situation. These scale model vehicles were presented at distances which would produce visual images of approximately the same sizes as full-scale vehicles seen through the XM65 gunsight (13X) at ranges of 3000 and 4000 meters.

The scale of 1/87 was selected for this research because of the ready availability of a wide variety of models of both threat and friendly armored vehicles in this scale. These models, even when viewed from a distance, were sufficiently detailed to present a well-defined image.

It would have been prefereable to have the observers view the scale model vehicles using the XM65 gunsight. However, these gunsights are available only in the "Q" and "S" models of the HueyCobra attack helicopter, and the availability of these helicopters is frequently limited because of gunnery and flight training exercises. Therefore, for this preliminary experiment, it was decided to design the reduced-scale situation for 7x50 binoculars. The XM65 gunsight mounted in a helicopter was used for the larger, main experiment.

The reduced-scale target presentation situation was designed so that observers viewing 1/87 scale models using 7x50 binoculars would see images of approximately the same size as if they were viewing full-sized armored vehicles at ranges of 3000 and 4000 meters using the XM65 gunsight adjusted to the 13 power setting. From these parameters, reduced-scale target presentation distances were calculated for 3000 meters and 4000 meters. These distances were 18.57 meters (61 feet) for the 3000 meter range, and 24.76 meters (81 feet) for the 4000 meter range. The derivation of the range adjustment equation which was used is described in Technical Appendix B.

The five scale model armored vehicles used in both the training and testing phases of this experiment were: M60 tank (without searchlight), M113 Armored Personnel Carrier (APC), Chieftain tank, T54 tank, and ZSU 57/2 Air Defense System (ADS). Two additional vehicles were used only in the testing phase to investigate the observers' responses to vehicles on which they were not trained in this experiment. These additional vehicles were the AMX 30 tank (with searchlight) and the PT76 Armored Reconnaissance Vehicle (ARV).

The Test Site

The test site for this experiment was established on a flat open area sparsely covered with short grasses and adjacent to the headquarters area of the 4/9 Cavalry, 6th US Cavalry Brigade (Air Combat), Fort Hood, Texas. The site was set up in the following manner. A target presentation point was established and marked with a wooden stake. Measuring south from this point, two observation points were located and marked with wooden stakes. The near observation point was located 18.57 meters (61 feet) from the target presentation point. As indicated previously, this scaled distance represents a 3000 meter range. The far observation point was located 24.76 meters (81 feet) from the target presentation point. This scaled distance represents a 4000 meter range. The test site was oriented in this manner to avoid problems of observation due to the sun "being in the observer's eyes."

A field telephone system was set up to provide communication between the experimenter at the target presentation point and the observer at one or the other of the two observation points. A platform was placed at the target presentation point. This platform consisted of two 12" x 24" plywood panels joined at a right angle along one of their long sides. One panel provided a horizontal surface on which the targets were placed, while the other panel formed a vertical background surface behind the target. The plywood panels were covered with papier mache to provide a textured background surface and painted a medium dark forest green. A Spectra illumination meter was located at the target presentation point to measure the ambient illumination available during the experiment.

Order of Target Presentations

During the training phase of the experiment, each of the five targets was presented to the observer at a scaled range of 3000 meters in three views (side, oblique, and front), yielding a series of 15 presentations. A similar, but different order of the 15 presentations was presented to the observer at a scaled range of 4000 meters. Before the data were gathered, 10 different random orders of the 15 vehicle/view combinations were constructed. Five of these 10 random orders were used for presentations at the 3000 meters scaled range, and the other five for presentation at the 4000 meters scaled range. Thus, the 10 different random orders of vehicle/view combinations provided presentations for five observers. The 10 random orders were then re-used for each succeeding group of five subjects, in the manner illustrated in Table 1. After the presentation sequences for all 20 observers were determined, presentations which involved either a side or oblique view were randomly designated as either right or left.

The target presentation sequences for the testing phase of the experiment were constructed in the same manner as those used in the training phase, except that seven target vehicles were used, thus resulting in 21 target presentations at each of the two ranges. The observers were not shown the two additional, different vehicles until they appeared in the presentation sequences during the testing phase of the experiment, and thus they did not know that any "ringers" would be presented. Examples of the target presentation sequences for the training and testing phases of the experiment are given in Technical Appendix C.

Table 1

Use of Ten Random Orders of Vehicle/View Combinations

Observer No.	3000 meters	4000 meters
1	1st Random Order	6th Random Order
2	2nd Random Order	7th Random Order
3	3rd Random Order	8th Random Order
4	4th Random Order	9th Random Order
5	5th Random Order	10th Random Order
6	1st Random Order	6th Random Order
7	2nd Random Order	7th Random Order
8	3rd Random Order	8th Random Order
9	4th Random Order	9th Random Order
10	5th Random Order	10th Random Order
11	1st Random Order	6th Random Order
12	2nd Random Order	7th Random Order
13	3rd Random Order	8th Random Order
14	4th Random Order	9th Random Order
15	5th Random Order	10th Random Order
16	1st Random Order	6th Random Order
17	2nd Random Order	7th Random Order
18	3rd Random Order	8th Random Order
19	4th Random Order	9th Random Order
20	5th Random Order	10th Random Order

Experimental Procedure

The data for this experiment were gathered on eight consecutive working days from 31 August 1976 through 10 September 1976, between 0900 and 1200 hours on each day. Generally, three one-hour training/testing sessions were scheduled on each of these days with one observer being trained and tested during each session.

Upon arrival at the test site, the observers were interviewed by the experimenter and the following information was obtained: observer's name, duty position, reported visual acuity, unit, and reported previous target recognition/identification training. Following this interview, the observers were briefed about the purpose of the research and given the following preliminary instructions concerning their participation in the research:

> This morning's testing will be conducted in two phases. During the first phase, I will show you a variety of vehicular targets at two simulated ranges, 3000 and 4000 meters. Each target will be defined by a particular type of vehicle and by one of three orientations (front, side, and oblique view). There will be a total of five vehicles presented. Thus, with five vehicles and three views per vehicle, there will be 15 targets shown at each simulated target range. After each target is presented you should indicate if the target is a threat or a friendly vehicle. Next, you should indicate the name of the vehicle. If you cannot tell me if it is a threat or friendly vehicle, or if you cannot name the target, I will give you the correct information. Also, if you incorrectly recognize and/or identify the target, I will give you the correct information. In addition, you will be given an opportunity to study the targets that you did not correctly identify. After this familiarization period has been completed, you will be given a few minutes to rest. Following this short rest period we will begin the second phase of the testing.
>
> During Phase II of the testing you will again be shown a variety of potential targets at the two simulated ranges. However, instead of 15 targets, there will be 21 targets in the test series for each range. Each target will be presented for, at most, five seconds. Immediately after

a target has been presented, you should tell me if it is a threat or a friendly target and what its name is. After you give me your answers, we will proceed directly to the next target in the series. Since in this phase of the testing, I am only interested in how well you can identify targets, I will not tell you if your answers are correct or incorrect. Also, if you cannot recognize and/or identify a given target, you should tell me, "I don't know."

After all testing has been completed, I will calculate the percentage of targets that you correctly recognized and identified at each range for both phases of the testing. This will provide you with an index of your target identification ability for the targets comprising the two test series. Also, if you are interested, I will tell you which targets you missed so that you can study these at your Threat Center.

One more thing. It is important that you do the best you can during the testing. While the results of this testing will be employed only for research purposes, the training that this testing will give you may be very important if you are ever in combat. As a consequence, by doing your best, you will benefit not only the Army in its threat recognition/identification research, but you will also benefit yourself. Now, are there any questions about what we are going to do? (Questions were answered at this point.) OK, we will proceed with the test program for this morning.

After the observers had received these instructions, they were escorted to either the near or far observation point (depending on the target range at which they were to begin their training) and seated on the ground. Next, they were handed a pair of military issue 7x50 binoculars to use when viewing the targets. Also, they were told to use the field telephone to communicate with the experimenter at the target presentation point.

Then the observers were given these instructions:

As I indicated in my introductory remarks, you will first be shown 15 targets at each of two simulated ranges. You will view these targets with the 7x50 binoculars that you have just been given. The physical distances at which the targets are located will

> simulate either a 3000 or 4000 meter range when viewed through the binoculars at the near or far observation point, respectively. Now I am going down to the target presentation point. When I get there I will show you a "C-ring" target. Look through your binoculars at this target and focus them until you can clearly see the gap in the target and the edges of the "C" are clear and distinct. When you have completed this task, raise your arm, then pick up your phone, and listen for the rest of my instructions.

After giving these instructions, the experimenter left the observer and went to the target presentation point. Next, he showed the observer a "C-ring" target so that the observer could focus his binoculars. When the observer raised his arm to indicate that the binoculars were properly focused and picked up his field phone, the following instructions were given to him via the phone:

> Now that your binoculars are properly focused, we will begin the first phase of testing. I will now present the first target. It and each additional target will be presented for, at most, 15 seconds, or until you make your responses. If after 15 seconds, you cannot correctly identify the target, I will tell you what it is, i.e., I will tell you if it is a friendly or a threat vehicle, and I will name it for you. Also, if your response is incorrect (in terms of either its friendly-threat nature or name), I will correct it for you. This procedure will be followed for all 15 target target presentations at this and the other simulated distance. Now, do you have any questions? (At this point, questions were answered.) OK, now we will begin.

The first series of 15 target presentations followed these instruction. These targets were presented in the following manner. A list of the particular target views had previously been prepared for each observer (see Technical Appendix C for a sample target list). For each target presentation the experimenter selected the appropriate target from the observer's target list, set it in the middle of the target

presentation platform at the specified angle, and started a stopwatch. After the target had been placed on the platform, the experimenter waited for the observer's response. If the observer's response was correct, the observer was told that the response was correct. If his response was incorrect, the correct information was given to the observer. At this point the observer's response was recorded on the target list. Also, after the observer had made responded to a target, the experimenter pointed out relevant features of the target that distinguished it from other targets of that particular class. A reading from the illumination meter located at the target presentation point was recorded on the target list after each target presentation. These procedures were repeated for each of the 15 targets in the first series of presentations.

After the first series of 15 targets had been presented at the first target range, the observer was instructed to move to the other observation point for additional target presentations. An additional 15 targets were presented to the observer at this range and his responses recorded. The procedure followed for these 15 presentations was the same as for the first series of 15 presentations. Thus, during the training phase, each observer was presented with a total of 30 targets, with feedback about the correctness of each of his reponses.

Following the training, the observer was given a two-minute rest break. Following the rest break, the observer was contacted on the field telephone and given the following instructions:

> We will now complete the second phase of testing. As I indicated in my introductory remarks, in this phase you will be presented with 21 targets at each of the two simulated ranges. As before, you will

observe the targets with the binoculars. When a target is presented you will have five seconds to indicate if it is a threat or friendly target and name it correctly. If after five seconds you cannot do this, we will proceed to the next target. After 21 targets have been presented at the first range, you will move to the other range and the next series of 21 targets will be presented. Remember, if you cannot recognize or identify a target, tell me, "I don't know." Do you have any questions? (At this point, any questions were answered.) OK, we will now begin.

Following these instructions, the first series of 21 targets (including three views of each of the two targets not presented before) were presented. The procedure was the same as during the training phase, with the exception that observers were given no feedback. After completing the first series, the observer was instructed to move to the other observation point and the final series of 21 targets was presented. After the last target was presented, the observer was told that the testing was completed and that he could come to the target presentation point for debriefing. The observers were shown the targets employed in the study and were told what percentage of these targets they had correctly identified during training and testing. Finally, the observers were instructed not to tell anyone about the details of the research. These instructions were intended to reduce the possibility that the performance of observers who were tested later would be biased.

RESULTS

The results of this experiment are presented in this chapter mainly in the form of the percentages of correct recognition and identification achieved by the observers. Statistical analyses are presented in greater detail in the Technical Appendixes. References to significant differences

in recognition and identification scores are based on the appropriate statistical analyses.

Derivation of Recognition and Identification Scores

The response of each observer to each target presented was scored for both recognition and identification. The scores assigned were 0 for incorrect recognition or identification, and 1 for correct recognition or identification. Table 2 illustrates in more detail how the recognition and identification scores were assigned.

In practice, the rules for deriving recognition scores were relatively lenient, while those for deriving identification scores were relatively strict. For example, observers often simply gave the name of a vehicle as their response. If the target vehicle presented was a threat vehicle, and vehicle named by the observer was also a threat vehicle, though not the one which had been presented, recognition was scored as correct (1), but identification was scored as incorrect (0). If the target vehicle presented was a friendly vehicle, but the vehicle named by the observer was a threat vehicle, recognition was scored as incorrect (0), and identification was also scored as incorrect (0). In order for identification to be scored as correct, the observer must have correctly named the vehicle as follows: M60, M113, Chieftain, T54 (or T55), ZSU 57, AMX 30, and PT 76. Identification of the T54 tank as a "T55" was accepted as correct because of the very minor differences between the two vehicles. The M113 APC was labeled as APC 111, 112, or M114 with some frequency; however, none of these responses was accepted as a correct identification.

Table 2

Illustrations of Recognition and Identification Scoring

Target Presented	Observer Response		Scores Assigned	
	Friendly/Threat	Name of Vehicle	Recog.	Ident.
M60 Tank	Friendly	M60	1	1
T54 Tank	Threat	T62	1	0
Chieftain Tank	Friendly	Did not know	1	0
ZSU 57/2 ADS	Friendly	ZSU 23	0	0
M113 APC	Threat	APC?	0	0
AMX 30 Tank	Did not know	Did not know	0	0
PT 76 ARV	Friendly	PT 76	0	1*

*This combination of responses (incorrect recognition with correct identification did not occur in the data.

Initial Recognition and Identification Performance

A major concern of the study at this point was to evaluate the effectiveness of the recognition/identification training which helicopter crew personnel had received before participating in this experiment. Therefore, only the data for the 17 observers who had received formal training in vehicle identification were used in the analyses of initial recognition and identification performance. Further, only the responses of these 17 observers to the first presentation of each of the five vehicles were used, since on later presentations of these vehicles in the training phase of the experiment the observers would have had the benefit of feedback on the correctness of their first responses. The data involved in these analyses are one recognition score and one identification score for each of the five vehicles for each of the 17 observers. Some of these scores are for 3000 meters scale range, and the rest for 4000 meters, depending on which range was initially used for each observer.

Table 3 presents the percent correct initial recognition and identification responses at the two target ranges for each of the five target vehicles. The overall recognition rate was 65 percent, and the overall identification rate was 38 percent. These rates seem low; however, it should be remembered that the responses were obtained at the very beginning of the experiment, perhaps before the observers had had a chance to "warm up" to their task.

These data seem to show poorer performance at 4000 meters scaled range than at 3000 meters for both recognition and identification, but

Table 3

Percent Correct Initial Recognition and Identification Responses for Observers Who Had Received Prior Identification Training (N = 17)

Recognition

Target Range	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
3000 m	75	100	50	62	75	72
4000 m	22	78	33	78	78	58
TOTAL	47	88	41	71	76	65

Identification

Target Range	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
3000 m	75	75	25	25	12	42
4000 m	11	67	33	33	22	33
TOTAL	41	71	29	29	18	38

statistical analyses (Technical Appendix D) show that these differences were not reliable.

The recognition rates for the five target vehicles varied from 41 percent to 88 percent. Likewise, the identification rates for the five target vehicles varied from 18 percent to 71 percent. Statistical analyses (Technical Appendix D) show that there are reliable differences among the five target vehicles in both recognition and identification rates.

It is also of interest to note that though the recognition rates for the two threat vehicles (T54 tank and ZSU 57/2 ADS) are relatively high (71 percent and 76 percent, respectively), the identification rates for these two vehicles are quite low (29 percent and 18 percent, respectively). Thus, the observers did fairly well at recognizing these vehicles as threat vehicles, but quite poorly at specifically identifying them.

Effects of Training on Recognition and Identification Performance

To evaluate the effects of the training phase of the experiment, the recognition and identification scores were rearranged from the presentation order into six blocks of five scores each. The five scores in the first block of recognition scores, for example, were the recognition scores for the first presentation of each of the five target vehicles. The five scores in the second block were those for the second presentation of each of the five target vehicles, etc. Table 4 shows the percent correct recognition and identification responses for each of the six presentation blocks during the training phase of the experiment.

Table 4

Percent Correct Recognition and Identification Responses for Six Presentation Blocks During Training Phase (N = 20)

	Presentation Block					
	1	2	3	4	5	6
Recognition	62	81	90	92	90	95
Identification	34	63	70	91	84	93

Clearly, both recognition and identification performance improved during the training phase. Statistical analyses (Technical Appendix E) show that this improvement was significant for both recognition and identification performance. The analyses also show that whether the observers had the target presentations at a simulated range of 3000 meters first and those at 4000 meters second, or visa-versa, made no significant difference in recognition or identification performance. These results show that the training methods produced sharp improvements in both recognition and identification performance reaching levels above 90 percent in only 30 trials.

Posttraining Recognition and Identification Performance

The results of the testing or posttraining phase of the experiment are presented and discussed in two sections. The first section deals with the data obtained from the observers' responses to the five vehicles on which they received training in this experiment. The second section deals with the data obtained from the observers' responses to the two additional vehicles on which they had not been trained in this experiment.

Five vehicles previously trained on. Table 5 presents the percent correct posttraining recognition and identification responses for the

Table 5

Percent Correct Posttraining Recognition and Identification Responses For All Observers Who Completed Training (N = 20)

Recognition

Target Range	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
3000 m	87	100	93	88	97	93
4000 m	90	100	92	82	98	92
TOTAL	88	100	92	85	98	93

Identification

Target Range	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
3000 m	82	100	83	83	97	89
4000 m	90	100	82	78	92	88
TOTAL	86	100	82	81	94	89

five vehicles on which the 20 observers had been trained in this experiment. It is clear that both recognition and identification performance improved substantially over their initial levels (see Table 3). This is particularly true for those vehicles on which the observers' initial recognition and identification performance had been relatively poor. It should be noted that, in contrast to the general pattern found in Table 3, identification rates rose to levels not much below recognition rates. It should also be noted that considerably more data were available on posttraining recognition and identification performance than on initial performance. Each of the 20 observers received six presentations of each of the five target vehicles (three views at 3000 meters, and three views at 4000 meters).

Variability of recognition and identification performance for the five different target vehicles is reduced in the posttraining phase, as compared to the initial recognition and identification scores in the training phase. However, statistical analyses of the posttraining data (Technical Appendix F) show that there are still reliable differences among the five target vehicles in both recognition and identification rates. The analyses also show that neither target range nor order of presentation (3000 meters - 4000 meters versus 4000 meters - 3000 meters) affected recognition or identification performance.

Two additional, unfamiliar vehicles. Table 6 presents the percent correct recognition and identification responses for the two additional vehicles presented to the observers during the posttraining phase of the experiment. These analyses utilized only the data obtained from the 17 observers who had received formal training in vehicle identification.

Table 6

Percent Correct Recognition and Identification Responses for Two Additional, Unfamiliar Vehicles (N = 17)

Recognition

Target Range	French AMX 30 Tank	USSR PT 76 ARV	TOTAL
3000 m	20	80	50
4000 m	16	78	47
TOTAL	18	79	48

Identification

Target Range	French AMX 30 Tank	USSR PT 76 ARV	TOTAL
3000 m	2	39	21
4000 m	0	33	17
TOTAL	1	36	19

The percent correct recognition and identification responses for the PT 76 ARV are roughly comparable to those for the other five vehicles at the beginning of the training phase (see Table 3). However, the percent correct recognition and identification responses for the AMX 30 tank were much lower. Statistical analyses (Technical Appendix G) show that highly reliable differences in both recognition and identification rates exist between the AMX 30 tank and the PT 76 ARV. Neither target range nor order of presentation (3000 meters - 4000 meters versus 4000 meters - 3000 meters) affected recognition or identification performance.

Effects of target view on recognition and identification performance. For both the training and posttraining phases, target presentation sequences were prepared so that target view (side, oblique, and front) was balanced, and the right-left aspect of the side and oblique views was randomized. Thus, vehicle view was a controlled factor. Originally, it had not been planned to investigate target view as a factor in recognition and identification performance, but during the target presentation phases of the experiment it was noted that for some vehicles, certain views seemed to be correctly recognized and identified more often than other views. Therefore, the posttraining data for the five vehicles previously trained on were tabulated and summarized with respect to target view. Table 7 shows the percent correct recognition and identification responses for each of the vehicles as a function of target view. Inspection of this table suggests that target view was related to accuracy of recognition and identification responses. Moreover, it appears that the views which showed higher recognition and

Table 7

Percent Correct Recognition and Identification Responses as a Function of Target View (N = 20)

		RECOGNITION	
		Target View	
Target Vehicle	Front	Oblique	Side
M60 Tank	98	89	82
M113 APC	100	100	100
Chieftain Tank	88	95	98
T54 Tank	75	95	85
ZSU 57/2 ADS	100	95	98
		IDENTIFICATION	
M60 Tank	95	80	82
M113 APC	100	100	100
Chieftain Tank	75	88	85
T54 Tank	70	92	80
ZSU 57/2 ADS	98	90	95

identification rates varied for different vehicles. For example, the front view of the M60 tank had higher recognition and identification rates than the oblique and side views, while the oblique and side views of the Chieftain and T54 tanks appeared to have higher recognition and identification rates than the front view. As a result of this tentative finding, the second experiment was expanded to include target view as a factor to be evaluated.

Misidentifications. When observers incorrectly identify vehicles, it is important to know what other vehicles are being confused with a given vehicle. This information can be used to develop training programs in vehicle identification which emphasize distinctions between frequently confused pairs of vehicles. Table 8 shows frequencies of the various misidentifications of the five target vehicles in the posttraining phase of the experiment. Also shown are the numbers of "I don't know" responses. Probably the most important piece of information in Table 8 is that the T54 tank, a threat vehicle, was most often (15 times) misidentified as an M60 tank (friendly). Generally, the misidentifications were scattered over friendly and threat vehicles, though the M60 tank was misidentified nine times as either a T54 tank or a ZSU 57/2 ADS.

As an aid in assessing the observers' reactions to the two additional, unfamiliar target vehicles presented in the testing or posttraining phase of the experiment, misidentifications were tabulated and are presented in Table 9. Only the data for the 17 observers with formal training in vehicle identification before participating in this

Table 8

Misidentifications: Five Target Vehicles
Previously Trained on (N = 20)

	Target Vehicles				
	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS
Friendly Vehicles					
M60	xxx		4	15	
SABER			4		
Chieftain			xxx	2	2
Leopard	1		1		
AMX 30			1		
Threat Vehicles					
T54	4		3	xxx	2
ZSU 57/2	5		2		xxx
T62				3	
ZSU 23-4					2
ASU 85			1		
"T70"				1	
"I don't know"	7		5	1	1
Total Misidentifications	10	0	16	21	6
Correct Identifications	103	120	99	98	113
TOTALS	120	120	120	120	120

Table 9

Misidentifications: Two Additional, Unfamiliar Vehicles (N = 17)

	Target Vehicles	
	French AMX 30 Tank	USSR PT 76 ARV
Friendly Vehicles		
M60	11	2
Chieftain	3	6
Centurion	1	
Leopard	1	
"M1970"	1	3
Threat Vehicles		
T54	33	10
T62	21	1
ZSU 57/2	4	2
BMP		6
"BPM"		4
PT 76	1	xxx
T34	1	
BTR 50		4
"I don't know"	24	27
Misidentifications	77	38
Correct Identifications	1	37
TOTAL	102	102

experiment were used in these tabulations. The numbers of misidentifications and "I don't know" responses were much greater for these target vehicles, of course, since the number of correct identifications was much smaller than for the five target vehicles on which training had previously been given. Table 9 shows that French AMX 30 tank was very frequently misidentified as a threat vehicle. Otherwise, the misidentifications are scattered and almost random.

Effects of Ambient Illumination on Recognition and Identification Performance

During both the training and posttraining phases of this experiment, illumination measurements were recorded for each target presentation. The measurements for the first presentation of each of the five target vehicles in the training phase were averaged for each of the 17 observers with formal training in vehicle identification. These average illumination levels ranged from 2280 to 9500 foot-candles. Because of this wide range, the average illumination levels were transformed to logarithms (base 10). Product moment correlation coefficients were then computed between log average illumination level and initial recognition and identification scores for the 17 observers. The correlation coefficients obtained are:

$r = .36$ (illumination level with recognition score)

$r = .04$ (illumination level with identification score).

Neither of these correlation coefficients is large enough to conclude that a statistically significant ($p \leq .05$) relationship exists.

In a similar fashion, the illumination measurements for the posttraining presentations of the five target vehicles were averaged for

each of the 20 observers. These average illumination levels ranged from 843 to 9967 foot-candles. Again, a log transformation was applied to the average illumination levels, and product moment correlation coefficients were computed with the posttraining recognition and identification scores. The correlation coefficients obtained are:

$r = .20$ (illumination level with recognition score)

$r = .24$ (illumination level with identification score)

Again, neither of these correlation coefficients is large enough to conclude that a statistically significant ($p \leq .05$) relationship exists.

Thus, it appears that within the rather wide range of illumination levels measured in this experiment, ambient illumination is not related to recognition or identification performance.

"Lessons Learned"

After examining the results of this preliminary experiment, a somewhat different design was developed for the larger, main experiment in this study. The main changes in the experimental design were:

(1) Order of presentation (3000 meters - 4000 meters versus 4000 meters - 3000 meters) was dropped as a factor, since no significant effects of this factor were found in the preliminary experiment. In the main experiment the range variable was associated with the two groups of observers, one group doing all of its observing at 3000 meters, and the other group at 4000 meters.

(2) A substantial series of pretraining trials, without feedback to the observers on the correctness of their responses, was given, in order to provide a larger data base for the measurement of initial recognition and identification performance.

(3) The design was expanded so that vehicle view was explicitly included as a factor to be evaluated in both the pretraining and posttraining phases of the experiment.

In addition, all of the observers who participated in the main experiment were helicopter pilots, so that all had had some formal training in vehicle identification, and might also serve as TOW gunners. This fact made it possible to make a better evaluation of the effectiveness of current recognition/identification training programs for helicopter pilots.

CHAPTER 3

MAIN EXPERIMENT

The second experiment was a larger experiment designed to remedy some of the shortcomings found in the preliminary experiment, and thus provide more and better information on the abilities of helicopter crew personnel to recognize and identify scale models of armored vehicles at scaled ranges of 3000 and 4000 meters. This will make possible a better assessment of their previous training for this task.

DESCRIPTION OF THE EXPERIMENT

Method

This main experiment was expanded over the preliminary experiment, so that it included a pretraining phase, a training phase, and a post-training or testing phase. In addition, the number of target presentations was increased so that target view was included as a factor to be analyzed, in addition to range and vehicle type.

Scale models of the same five armored vehicles as were used in the preliminary experiment (M60 tank, M113 APC, Chieftain tank, T54 tank, and ZSU 57/2 ADS) were presented to the observers. Each scale model was presented in five different views (side left, oblique left, front, oblique right, and side right) throughout all three phases of the experiment. Each observer was asked to indicate whether the vehicle was a friendly or a threat vehicle, and then to name (identify) the vehicle.

Two groups of 10 observers each participated in this experiment. One group of 10 observers viewed all targets presented to them during the pretraining, training, and posttraining phases of the experiment at

a scaled range of 3000 meters, while the other group of 10 observers viewed all targets at a scaled range of 4000 meters.

During the pretraining phase of the experiment, a series of 25 target presentations (all five targets in all five views) was made to each observer. No information was given to the observer during the pretraining phase as to the correctness of his responses.

During the training phase of the experiment each observer was given up to 50 presentations of all five of the vehicles in all five views. In the training phase the observer was told whether his responses were correct, and if they were incorrect, he was given the correct information. The target presentations during the training phase were made in blocks of five. Training was terminated when the observer correctly identified all of the targets presented in two successive blocks.

In the posttraining phase of the experiment each observer was given a series of 25 target presentations (all five targets in all five views) in a different order than during the pretraining phase. No feedback as to correctness of responses was given to the observer during the posttraining phase. Finally, at the end of the posttraining phase an additional series of seven target presentations was made -- the five vehicles used in the earlier parts of the experiment, plus two additional vehicles (AMX 30 tank and PT 76 ARV) which had not previously been shown to the observer in this experiment.

The 25 target presentations during the pretraining phase were intended to provide a substantial data base for the measurement of initial recognition and identification performance. These measurements

will allow some judgments as to whether current training programs in target identification are adequate to ensure that helicopter crew personnel will be able to recognize and identify armored vehicles at standoff ranges. The data from the pretraining phase of the experiment was also intended to provide information on the effects of simulated target range, vehicle type, and vehicle view on recognition and identification performance.

The training phase of the experiment was intended to provide information about how much training was required to raise the recognition/identification performance levels of helicopter crew personnel to practically 100 percent.

The posttraining phase of the experiment was intended to confirm that the observers' performance levels had indeed reached a high level, and to provide information on whether any lingering recognition/identification problems remained, at least for the five vehicles used throughout the experiment. Finally, the introduction of the two additional vehicles in the last series of seven target presentations was intended to provide further information on the reaction of helicopter crewmen to unfamiliar targets.

Observers

The observers for this experiment were 20 officers from the 4/9 Cavalry, 6th US Cavalry Brigade (Air Combat), Fort Hood, Texas. All of the observers were qualified helicopter pilots, and all had received formal training in target identification.

Simulation of the Environment

The same 1/87 scale model vehicles were used in this experiment as had been used in the preliminary experiment. However, it was possible to obtain a helicopter with an XM65 gunsight for this experiment. Thus, the calculation of the appropriate scaled ranges was very simple:

For 3000 meters, 3000 ÷ 87 = 34.48 meters (113 feet)

For 4000 meters, 4000 ÷ 87 = 45.98 meters (151 feet).

The Test Site

The test site for this experiment was located at the Fort Hood Army Airfield, where an attack helicopter with an XM65 gunsight was made available for the research. The helicopter was parked on the airfield so that an unimpeded line of sight, looking north from the helicopter, was available. During the times when data were being gathered, an auxiliary power unit was used to supply power to the helicopter so that the XM65 gunsight could be operated.

The helicopter served as the observation point. Two target presentation points were established along the line-of-sight to the north of the helicopter. The near target presentation point was 34.48 meters (113 feet) from the helicopter, corresponding to a range of 3000 meters; while the far target presentation point was 45.98 meters (151 feet) from the helicopter, corresponding to a range of 4000 meters. With this arrangement, the observer was always looking north at the targets, and thus the problem of the sun "being in the observer's eyes" was avoided.

The target presentation platform (the same green papier mache covered platform used in the preliminary experiment) was placed on a

small table at either the near or far target presentation point. A field telephone system was set up to provide communication between the observer in the helicopter and the experimenter at one or the other of the two target presentation points. Finally, a Spectra illumination meter was obtained to measure target illumination.

Order of Target Presentations

The target presentation sequences for this experiment were prepared in the following manner. First, a basic set of 25 target presentations -- the five target vehicles x the five target views -- was constructed. Then 10 different random orders of this basic set of 25 target presentations were prepared. The random ordering of the 25 target presentations was constrained so that they appeared in blocks of five. All five of the target vehicles appeared in each block, and also, all five of the target views appeared in each block. One of these 10 random orders of the 25 target presentations may be found in Technical Appendix H.

In the pretraining phase of the experiment, one of the ten different random orders of the 25 target presentations was used for each of the ten observers who observed the target vehicles at a scaled range of 3000 meters. In a similar manner the same 10 random orders of 25 target presentations were used for the group of 10 observers who observed the target vehicles at a scaled range of 4000 meters.

Target presentation sequences for the training phase of the experiment were prepared in the following manner. For each of the 20 observers a different random order of the 25 target presentations than he had

been shown in the pretraining phase was selected. This set of 25 target presentations was used for the first half of the 50 target presentations needed. Then this set of 25 target presentations was reproduced, in reverse order and with the left-right aspects of the side and oblique views reversed, to complete the required 50 target presentations.

During the posttraining phase, the same 10 random orders of 25 target presentations were re-used, with each observer receiving a different order than he had been shown in either the pretraining or training phases. The final series of seven target presentations was constructed by selecting one random order of the five target vehicles previously used for each observer. One of the five views was then randomly assigned to each of the target vehicles. Then two additional target vehicles -- the AMX 30 tank and the PT 76 ARV -- were inserted together at a random point in each series of five target vehicles. Although the two additional vehicles always appeared together, the order of appearance was balanced in both the 3000 meter and 4000 meter presentations. The views shown of these two additional vehicles were assigned so that the five target views of each vehicle were balanced over the 3000 meter and 4000 meter range groups, and within these groups, over the two order subgroups.

Experimental Procedure

The data for this experiment were gathered on 10, 11, 14, 17, and 19 January 1977, at various times of day from 0830 to 1600. The experimenter met each observer at the observation point, which was an attack

helicopter equipped with an XM65 gunsight. The gunsight was energized and adjusted to the 13X setting.

The experimenter obtained from each observer the following information: name, rank, MOS and job, unit assignment, whether he wore glasses, and the number of hours of previous recognition/identification training. The observer then entered the helicopter and was familiarized with the M65 gunsight (if he were not already familiar with this sight). The experimenter then went to the target presentation point to be used for this observer. A scale model M48 tank was placed on the target presentation platform and the observer was asked to focus the gunsight so that he could clearly see this target vehicle. The following instructions were then read to him on the field telephone:

> This morning's testing will be conducted in three phases. During the first phase, I will show you a variety of vehicular targets at a simulated range of 3000 (or 4000) meters. Each target will be defined by a particular type of vehicle and by one of five orientations (front, side left, side right, oblique left, and oblique right view). There will be a total of five vehicles presented. Thus, with five vehicles and five views per vehicle, you will be shown 25 targets. After each target is presented you should indicate if the target is a threat or a friendly vehicle. Next, you should indicate the name of the vehicle. Since in this phase of the testing I am interested in how well you can recognize and identify targets, I will not tell you if your answers are right or wrong. After all targets have been presented, this phase of the testing will be ended and there will be a short rest break.
>
> During Phase II of the testing I will again present you with a variety of targets. These will be the same targets that you saw in Phase I of the testing. After each target presentation, you should, as before, first indicate if it is a threat or friendly target and then name it. If you cannot tell me if it is a threat or friendly vehicle, or if you cannot name the target, I will

give you the correct information. Also, if you incorrectly recognize or identify the target, I will give you the correct information. In addition, you will be given an opportunity to study the targets that you did not correctly identify. You will continue this procedure for 50 trials or until you can correctly recognize and identify all of the targets in two successive groups of five targets. After this task has been completed, you will be given a two-minute rest. Following this rest period we will begin the third phase of the testing.

During Phase III of the testing you will again be shown a variety of potential targets. There will also be 25 targets shown to you in this phase of testing. These will be the same as those you saw during the previous phase. In addition, at various times some targets you have not seen previously may be shown to you to further test your knowledge of armored vehicles. Each target will be presented for, at most, five seconds. Immediately after a target has been presented, you should tell me if it is a threat or a friendly target and what its name is. After you give me your answers, we will proceed directly to the next target in the series. Since in this phase of the testing I am interested in how well you can identify targets, I will not tell you if your answers are correct or incorrect. Also, if you cannot recognize or identify a given target, you should tell me, "I don't know."

After all testing has been completed, I will tell you what percentage of targets that you correctly recognized and identified for each phase of the testing. This will provide you with an index of your target identification ability for the targets you have seen during the testing. Also, if you are interested, I will tell you which targets you missed so that you can study these at your Threat Center.

One more thing. It is important that you do the best you can during the testing. While the results of this testing will be employed only for research purposes, the training that this testing will give you may be very important to you if you are ever in combat. As a consequence, by doing your best, you will benefit not only the Army in its threat recognition/identification research, but you will also benefit yourself. Now, are there any questions about what we are going to do? (Questions were answered at this point.)

As I indicated in my introductory remarks, you will first be shown 25 targets at one of the two simulated ranges. You will view these targets through the XM65 gunsight. The physical distance at which the targets are located will simulate a 3000 (or 4000) meter range when viewed through the gunsight.

We will now begin the first phase of testing. I will present the first target. It and each additional target will be presented for, at most, 15 seconds, or until you make your response. If, after 15 seconds, you cannot correctly identify the target, I will show you the next target. This procedure will be repeated until all 25 targets have been presented. Now, do you have any questions? (At this point any reasonable questions were answered.) OK, we will now start.

Following these instructions the pretraining phase was begun. The experimenter, following the target presentation list prepared for this particular observer, selected the appropriate target, placed it in the middle of the target presentation platform at the proper angle, and started a stopwatch. After the target vehicle had been placed on the platform, the experimenter listened to the field telephone for the observer's response. When the observer responded, or after 15 seconds, the experimenter made the appropriate entries on the target presentation list (including noting the reading on the illumination meter), and went on to present the next target vehicle. These procedures were continued until all 25 vehicles in the pretraining presentation series had been shown to the observer. He was then given a short rest break.

The training phase was then begun. The same procedures were followed as in the pretraining phase, except that feedback was given to the observer after each target vehicle presentation. If the observer's response was correct, he was told that it was correct. If either the recognition or identification response, or both, were incorrect, the

observer was given the correct information, and features of the target that distinguished it from other similar targets were pointed out. Appropriate entries, depending on the observer's responses, were made on the target presentation list. Presentations of target vehicles were continued until the observer had correctly identified two successive groups of five targets, or until all 50 target vehicles had been presented. The observer was then given a second rest break.

After this rest break, the following instructions were given on the field telephone:

> We will now complete the third phase of testing. As I indicated in my introductory remarks, in this phase you will be presented with a number of targets at 3000 meters (or 4000 meters) scale range. As before, you will observe the targets through the gunsight. When a target is presented you will have five seconds to indicate if it is a threat or friendly target and name it correctly. If, after five seconds, you cannot do this, we will proceed to the next target. After all targets have been presented, the testing will be completed. Remember, if you cannot identify a target, tell me "I don't know." Do you have any questions? (At this point any questions were answered.) OK, we will now begin.

The posttraining phase was then carried out, following the same general procedures as those used in the pretraining phase (no feedback was given). However, instead of 15 seconds, only five seconds was allowed for the observer to respond to each target vehicle. After the 25 target presentations and the additional seven target presentations were completed, the observer was given information on his recognition and identification performance. Finally, before the observer left, he was asked not to tell anyone about the details of the research procedures, to avoid influencing the performances of others who were tested later.

RESULTS

The results of this experiment are presented in this chapter in the same general fashion as those of the preliminary experiment were presented in Chapter 2. Recognition and identification scores were derived from the observers' responses by the same rules used in the preliminary experiment (see Chapter 2).

Pretraining Recognition and Identification Performance

The 25 target vehicle presentations for each observer in the pretraining phase of this experiment provide a much larger data base for inferences concerning the initial recognition and identification capabilities of helicopter pilots than the five trials for each observer in the preliminary experiment. With this larger data base it is also possible to determine the effect of target view, as well as of range and vehicle type, on recognition and identification performance. Further, it was possible to determine whether learning occurred in the absence of feedback during the 25 target vehicle presentations.

Table 10 shows the percent correct pretraining recognition and identification responses at the two target ranges for each of the five target vehicles. The first thing to be noted is that both recognition and identification rates are substantially higher than in the preliminary experiment, except for the M113 APC, for which the rates were quite high in the preliminary experiment. This raises the possibility that some learning (even in the absence of feedback) occurred during the 25 target vehicle presentations in this experiment, thus raising the average recognition and identification rates above those found in the

Table 10

Percent Correct Pretraining Recognition and Identification Responses for Five Target Vehicles (N = 20)

Recognition

Target Range	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
3000 m	96	88	86	86	98	91
4000 m	84	96	72	66	86	81
TOTAL	90	92	79	76	92	86

Identification

Target Range	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
3000 m	74	78	62	60	80	71
4000 m	52	76	48	36	46	52
TOTAL	63	77	55	48	63	61

preliminary experiment, which were based on the first presentation of each of the five target vehicles to each observer. This possibility will be examined shortly.

It is of interest to note that the differences between recognition and identification rates for the five vehicles are more stable in this experiment than in the preliminary experiment. This would be expected because of the larger data base in this experiment, which justifies more confidence in the recognition and identification rates obtained in this experiment than in those obtained in the preliminary experiment. Specifically, in this experiment the identification rates for the T54 tank and the ZSU 57/2 ADS did not drop so far below their recognition rates, as happened in the preliminary experiment.

Table 11 presents the percent correct pretraining recognition and identification responses at the two target ranges for each of the five target views presented to the observers. The data on target views show a remarkably consistent pattern. The recognition rate for the front view for both range groups combined is 14 to 19 points lower than for other views. The identification rate for the front view is 10 to 15 points lower than for other views.

Statistical analyses of initial target recognition and identification performance were carried out (Technical Appendix I). These analyses considered jointly target range, vehicle type, and target view. In summary, these analyses show that the differences between the two target ranges and among the five vehicle types shown in the data of Table 10 are not reliable, but that there are reliable differences among the five target views, as shown in Table 11. Thus, it is clear that it

Table 11

Percent Correct Pretraining Recognition and Identification Responses for Five Target Views (N = 20)

Recognition

Target Range	Left Side	Left Oblique	Front	Right Oblique	Right Side	TOTAL
3000 m	92	94	80	94	94	91
4000 m	80	84	64	88	88	81
TOTAL	86	89	72	91	91	86

Identification

Target Range	Left Side	Left Oblique	Front	Right Oblique	Right Side	TOTAL
3000 m	72	74	60	76	72	71
4000 m	50	54	42	56	56	52
TOTAL	61	64	51	66	64	61

is more difficult to recognize or identify an armored vehicle when a front view is presented.

Further, the statistical analysis of recognition performance showed that there was a significant interaction between vehicle type and target view. The nature of this interaction may be determined by examining the data of Table 12, which shows percent correct pretraining recognition responses, for both range groups combined, for vehicle type by target view. In Table 12, it can be seen that generally the percent correct recognition responses in the row for the front target view are lower, as would be expected from the data shown in Table 11. However, the percent correct recognition responses for the front view of the T54 tank is much lower than the recognition rates for the front views of the other vehicles. This is the source of the significant interaction. The interpretation of this finding is that the T54 tank is particularly difficult to recognize as a threat vehicle when seen in a front view. No comparable finding for identification performance was made.

Statistical analyses of initial recognition and identification responses in the preliminary experiment showed reliable differences among vehicle types, but this was not found in the main experiment. This apparent discrepancy between the findings of the two experiments is due to the design of the preliminary experiment which did not provide a means for analyzing the effects of target view on recognition and identification performance. In the preliminary experiment the effects of vehicle type and target view were confounded, and it was not possible under the circumstances of the preliminary experiment to balance target view over the five vehicle types. Thus, the conclusion is that the

Table 12

Percent Correct Pretraining Recognition Responses, for Both Range Groups Combined, for Vehicle Type by Target View

	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS	TOTAL
Left Side	95	90	80	75	90	86
Left Oblique	80	95	85	90	95	89
Front	75	85	65	45	90	72
Right Oblique	100	95	80	90	90	91
Right Side	100	95	85	80	95	91
TOTAL	90	92	79	76	92	86

finding of reliable differences in recognition and identification performance for different vehicle types in the preliminary experiment was an artifact of an incomplete and imperfect experimental design, and that it is target view which affects recognition and identification performance, as shown by the main experiment.

Evidence for Learning During Pretraining Target Presentations

Table 13 presents percent correct recognition and identification responses, for the 25 pretraining trials in order of presentation. Data for the two range groups were combined, since significant differences were not found between them. In Table 13, a slight tendency can be seen for recognition and identification performance to improve after the first few target vehicle presentations. Statistical analyses (Technical Appendix J) show this tendency to be significant for recognition performance, but not so for identification performance.

Thus, it seems likely that data from the preliminary experiment somewhat underestimate the pretraining recognition and identification capabilities of the observers, and in turn, the adequacy of the training they have received. The main experiment provides much more data and therefore is likely to yield more reliable conclusions. Further, the larger number of presentations allows performance to stabilize, and thus yields better measures of recognition and identification performance. This stabilization of performance perhaps should not be referred to as learning; it seems more like a "warm-up" effect.

Recognition and Identification Performance During the Training Phase

The training phase of this experiment was conducted somewhat differently from the training phase of the preliminary experiment. In this

Table 13

Percent Correct Recognition and Identification Responses for the 25 Pretraining Trials in Order of Presentation (N = 20)

Presentation No.	Recognition	Identification
1	65	50
2	85	45
3	85	50
4	75	55
5	75	40
6	65	45
7	85	65
8	75	65
9	95	65
10	95	65
11	90	60
12	90	65
13	90	75
14	100	70
15	90	65
16	80	60
17	95	75
18	100	60
19	80	55
20	85	55
21	90	75
22	90	75
23	90	65
24	85	55
25	90	75
TOTAL	86	61

experiment, observers were considered to have reached criterion performance when they had correctly identified all of the target vehicles presented in two successive groups of five. Thus, the number of target vehicle presentations to reach criterion could range from 10 to 50, in steps of five. The numbers of presentations to reach criterion for the 20 observers did, in fact, cover this whole range, with most of them concentrated at 10, 15, and 20. The average number of target vehicle presentations to reach criterion for the group observing at 3000 meters scaled range was 17, while the average number of presentations to criterion for the group observing at 4000 meters scaled range was 27. A two-tailed Mann-Whitney U test shows ($p < .05$) that a greater number of target presentations is required to reach criterion for the group observing at 4000 meters scaled range than for the group observing at 3000 meters scaled range.

The percent correct recognition responses was computed for each observer, for the number of target vehicles presented to that observer during the training phase of the experiment. Recognition scores ranged from 80 percent to 100 percent for the 20 observers. The average percent correct recognition score for the group observing at 3000 meters scaled range was 96.5 percent, while the average percent correct recognition score for the group observing at 4000 meters scaled range was 92.8 percent. A Mann-Whitney U test shows no statistically significant difference in percent correct recognition responses between the group observing at 3000 meters and the group observing at 4000 meters.

The percent correct identification responses were computed for each observer also. These identification scores ranged from 65 percent to

100 percent. The average percent correct identification score for the 3000 meter group was 93.2 percent, while for the 4000 meter group the average score was 85.4 percent. A Mann-Whitney U test shows that the difference in percent correct identification responses between the 3000 meter group and the 4000 meter group fell slightly short of statistical significance ($.10 > p > .05$, two-tailed test).

In summary, nearly all of the observers learned to identify the target vehicles quickly and easily. Only one observer failed to reach the criterion of two consecutive groups of five correct identifications before completion of the 50 target presentations.

Posttraining Recognition and Identification Performance

Five vehicles previously trained on. Recognition and identification performance during the main posttraining series of 25 target presentations was very nearly perfect. Table 14 presents the percent correct recognition and identification responses for the two range groups, and for the total group of observers.

Table 14

Posttraining Percent Correct Recognition and Identification Responses (N = 20)

	Recognition	Identification
TARGET RANGE		
3000 m	99.6	99.2
4000 m	98.4	98.0
TOTAL	99.0	98.6

Since there was literally almost no variance in these posttraining data, no further analyses were done. The conclusion simply is that the observers had learned to identify the targets practically perfectly.

Two additional, unfamiliar vehicles. The final series of seven target presentations in the posttraining phase included one presentation each of two unfamiliar vehicles (the AMX 30 tank and the PT 76 ARV). These two vehicles had not previously been shown to the observer in this experiment. Table 15 shows the percent correct recognition and identification responses for these two additional, unfamiliar vehicles. Recognition performance on the five familiar vehicles in this final series of seven target presentations was nearly perfect, with only one identification error.

Statistical analyses were carried out on recognition and identification scores for these two additional, unfamiliar targets (Technical Appendix K). These analyses considered jointly target range, order of presentation (whether the observer was shown the AMX 30 first and the PT 76 second, or vice versa), and the two vehicle types. Briefly, these analyses show that the differences between the two target ranges and the two orders of presentation are not significant. The difference between the AMX 30 tank and the PT 76 ARV in percent correct identification responses was highly significant ($p < .001$), but the corresponding difference in percent correct recognition responses was not significant. Additional statistical analyses (also in Technical Appendix K) of the effects of target view on recognition and identification of the AMX 30 tank and the PT 76 ARV show no significant effects of target view. It should be noted that these analyses, particularly those of target view,

Table 15

Percent Correct Recognition and Identification Responses for Two Additional, Unfamiliar Vehicles (N = 20)

RECOGNITION

	French AMX 30 Tank	USSR PT 76 ARV	TOTAL
TARGET RANGE			
3000 m	50	90	70
4000 m	80	90	85
TOTAL	65	90	77.5

IDENTIFICATION

	French AMX 30 Tank	USSR PT 76 ARV	TOTAL
TARGET RANGE			
3000 m	10	60	35
4000 m	20	60	40
TOTAL	15	60	37.5

are based on very small amounts of data. Thus, any differences would have to be relatively large in absolute terms to be identified as statistically significant. In summary, the only significant finding concerning the recognition and identification of these two additional, unfamiliar vehicles was that identification of the AMX 30 tank was much poorer than that of the PT 76 ARV. Misidentification data for these two vehicles are presented in the next section.

Misidentifications

In the posttraining data for the five target vehicles on which training had previously been given, there were very few misidentifications. Out of the whole set of 500 target vehicle presentations, the M60 tank was misidentified once as a Chieftain tank, twice as a T54/55 tank, once as a ZSU 57/2 ADS, and once as unknown; and the Chieftain tank was misidentified twice as a T54/55. Since the posttraining data provided so few misidentifications, the misidentifications for the pretraining data are presented in Table 16.

The pattern of misidentifications in this experiment is varied, as might be expected, since these are pretraining misidentifications. Of all the misidentifications of the M60 tank, almost as many were threat vehicles as were friendly vehicles. The M60 tank also elicited a substantial number of "I don't know" responses. The misidentifications of the M113 APC were all slight mistakes in naming the vehicle, which probably would not be serious on the battlefield. The British Chieftain tank was frequently misidentified as a threat vehicle, whereas the USSR T54 was misidentified as a friendly vehicle less often, though still

Table 16

Pretraining Misidentifications: Five Target Vehicles

	Target Vehicles				
	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS
Friendly Vehicles					
M48	6			6	
M60	xxx		2	7	1
Centurion	1		8		
Chieftain	1		xxx	1	
"British"			1		
111, 112, M114, APC 114, APC?, APC 105		15			
XM70			3		
Sheridan	1				
Leopard	2				
AMX 30			1		
AMX 13			2		
M551	1				

cont'd

Table 16 (cont'd)

	Target Vehicles				
	US M60 Tank	US M113 APC	British Chieftain Tank	USSR T54 Tank	USSR ZSU 57/2 ADS
Threat Vehicles					
T62	3		9	21	1
T54/55	4		1	xxx	4
ZSU 23/4, T23/4	1				6
BMP			4		
T60				3	
ZSU 73					2
T10			2		
P76			1	1	
ASU 85, 85			1		1
ASU 87					1
"Assault Gun," BRDM					2
"I don't know"	17	8	10	13	19
Correct Identifications	63	77	55	48	63
TOTALS	100	100	100	100	100

with some frequency. The USSR 57/2 ADS was misidentified frequently, but almost always as a threat vehicle, or as an unknown.

The misidentifications for the two additional, unfamiliar target vehicles presented during the posttraining phase are shown in Table 17. Although each observer saw each of these vehicles only once in this experiment, compared to six times in the preliminary experiment, the percentage of misidentifications was approximately the same. Misidentifications of the AMX 30 tank were about equally distributed over friendly and threat vehicles, while the misidentifications of the PT 76 ARV were all threat vehicles.

Effects of Illumination on Recognition and Identification Performance

Since there was so little variance in the posttest recognition and identification data in this experiment, data on illumination level were examined only in relation to pretraining recognition and identification performance. The illumination measurements for the 25 pretraining target presentations were averaged for each of the 20 observers. These average illumination levels ranged from 240 to 3000 foot-candles. A log transformation (base 10) was applied to the average illumination levels, and product moment correlation coefficients were computed with the pretraining recognition and identification scores. The correlation coefficients obtained are:

$r = .07$ (illumination level with recognition score)

$r = .03$ (illumination level with identification score).

Neither of these correlation coefficients is large enough to conclude that a statistically significant (i.e., $p \leq .05$) relationship exists.

Table 17

Misidentifications: Two Additional, Unfamiliar Vehicles

	TARGET VEHICLES	
	French AMX 30 Tank	USSR PT 76 ARV
Friendly Vehicles		
M60	7	
Leopard	1	
Threat Vehicles		
T54/55	4	1
T62	3	1
T10		1
BRDM		1
Amphibious BTR		1
"I don't know"	2	3
Correct Identifications	3	12
TOTAL	20	20

A Mann-Whitney U test was used to determine whether the illumination levels under which the 3000 meter group observed differed significantly from those under which the 4000 meter group observed. This test showed no statistically significant difference in illumination levels between the two groups.

Relationship of Prior Recognition/Identification Training to Recognition and Identification Performance

Before the target presentation sessions began, the observers in this experiment were asked to estimate the number of hours of recognition/identification training they had previously received. The number of hours of prior recognition/identification training reported by the observers ranged from one to 30 hours, except for one observer, an intelligence officer who reported an estimated minimum of 1000 hours. Product moment correlation coefficients were computed between hours of prior recognition/identification training and the pretraining recognition and identification scores for the group of 20 observers. The correlation coefficients obtained are:

$r = .09$ (prior recognition/identification training with recognition score)

$r = .11$ (prior recognition/identification training with identification score).

Neither of these correlation coefficients is large enough to conclude that a statistically significant (i.e., $p \leq .05$) relationship exists. Finally, a Mann-Whitney U test was used to evaluate whether the amounts of prior recognition/identification training reported by the 3000 meter group differed significantly from those reported by the 4000 meter group. It should be noted that since the Mann-Whitney U test is based

on ranks, the extreme 1000 hour score of the one observer would not unduly affect the results of the test. The test indicated that the two groups of observers did not differ significantly in reported amounts of prior recognition/identification training.

CHAPTER 4

SUMMARY AND DISCUSSION OF RESULTS

The results of the two experiments conducted in this study unequivocally show that armored vehicles can be identified at ranges of 3000 to 4000 meters using the XM65 gunsight. The major qualification of this clear finding is that these two experiments were conducted under ideal viewing conditions, and it remains for further research to explore the effects on target identification capability of such degrading factors as camouflage and partial obscuration of targets, noise and vibration of the helicopter, atmospheric effects, low illumination levels, and low target-background contrast ratios.

Effectiveness of Current Training

The answer to the question, "How effective is the current training in vehicle identification received by helicopter crewmen"? is not very clear. First, an answer to this question requires that a judgment be made as to whether the pretraining levels of recognition and identification performance measured in this study are really adequate for the demands of battlefield performance. Pretraining recognition performance in the major experiment ranged from 76 percent to 92 percent for different vehicles, but from 64 percent to 100 percent for different individual observers. Pretraining identification performance in the main experiment ranged from 48 percent to 77 percent for different vehicles, but from 8 percent to 100 percent for different individual observers. Is this good enough? This question can be answered only by proper Army authority, but the research staff suspects that experts

would agree that the level of performance exhibited in pretraining was inadequate.

Second, no relationship was found between the amount of reported prior recognition/identification training and either recognition or identification performance as measured in these experiments. This raises the question of whether the recognition/identification training now being given contributes much toward developing recognition and identification capability, as measured in this study. An answer to this question would require much more intensive inquiry into the nature and amount of vehicle recognition/identification training given to helicopter crewmen than was possible in this study.

Effectiveness of Training Given in These Experiments

The training given in these two experiments, though brief (not more than 30 minutes), sharply improved the recognition and identification performances of the observers to approximately 85-98 percent correct recognition and approximately 80-90 percent correct identification in the first experiment, and to 98-99 percent correct for both recognition and identification in the second experiment. This very positive conclusion must be tempered by noting that the training was quite congruent with the kind of performance measured in evaluating posttraining recognition and identification capabilities in these experiments. Therefore, one would expect the training to be quite effective. If recognition and identification performance were measured in a full-scale field study at the actual ranges of 3000 and 4000 meters, even under ideal conditions, one might expect this kind of training at scaled ranges with scale

models to be slightly less effective in improving field recognition and identification performance than it was in improving performance in reduced-scale testing situations in these experiments.

Another factor that should be noted is that only five target vehicles were used in the training phases of these experiments. An operational training program designed to prepare men to identify armored vehicles on a central European battlefield would have to cover a considerably larger number of vehicles, and it could be expected that training on a larger number of vehicles would take somewhat longer to improve recognition and identification performance by the same amounts as occurred in these studies. Nevertheless, the training methods used in these studies should be quite effective in operational training programs, and it is planned that research during the year following this report will explore the feasibility of using these kinds of training methods in operational training programs in armored vehicle identification.

Factors Which Influence Recognition and Identification Performance

A major finding of these two experiments is that some factors which might have been expected to be related to recognition and identification performance apparently are not. For example, it might have been expected that recognition and identification performance would have been poorer at longer range. The data do point in this direction, but in none of four statistical analyses of recognition performance, and four more of identification performance, involving the five target vehicles used throughout the two experiments, were the differences in performance

at the two ranges large enough to reach statistical significance. The only statistically significant effect found for range was in number of target presentations needed to reach criterion in the training phase of the main experiment. Observers working at 4000 meters scaled range required more target presentations to reach criterion than did those working at 3000 meters scaled range.

In the preliminary experiment it appeared that there were significant differences in recognition and identification performance between the five vehicle types. However, the effects of target view were confounded with those of vehicle type in this experiment, and when the main experiment was extended so that both vehicle type and target view could be analyzed, the pretraining results indicated that differences between the five vehicle types in recognition and identification performance <u>were not</u> statistically significant, while those between the five different target views <u>were</u> statistically significant. Therefore, it is concluded that target view has a more potent effect on recognition and identification performance than does vehicle type for the five vehicle types used. The posttraining data in the main experiment showed almost negligible variance, because both recognition and identification performance were nearly perfect. Therefore, analyses of the effects of range, vehicle type, and target view were not carried out on this data.

Observers viewed the targets presented in these two experiments under a wide range of daylight illumination levels, but no effects of illumination level on recognition and identification performance were found. Obviously at lower illumination levels, such as might be found

at dusk or night, recognition and identification performance would be adversely affected.

Two Additional, Unfamiliar Vehicles

Both of these experiments included, in the posttraining phases, presentations of two additional vehicles which had not been shown to the observers earlier in the experiments. One of these, the PT 76 ARV, was recognized and identified about as well as the five target vehicles were in the pretraining or initial phases of the experiments, but the other vehicle, the AMX 30 tank, was correctly recognized and identified with a very low frequency. The PT 76 ARV was correctly recognized as a threat vehicle 80-90 percent of the time, even though it was correctly identified only 35-60 percent of the time. However, the AMX 30 tank was misrecognized as a threat vehicle as often, or more often than it was correctly recognized as a friendly vehicle.

Misidentifications

The M60 tank and the Chieftain tank were misidentified as threat vehicles about as often as they were misidentified as other friendly vehicles, and the T54 tank was misidentified as a friendly vehicle about as frequently as it was misidentified as another threat vehicle. The ZSU 57/2 ADS was seldom misidentified as a friendly vehicle, while the M113 APC was never misidentified as a threat vehicle.

CHAPTER 5

ADDITIONAL TOPICS

This chapter will briefly discuss two topics: the effectiveness of simulated fire versus live fire for training gunners for the COBRA-TOW attack helicopter system, and fatigue effects of night vision goggle (AN/PVS-5) use. Research had been planned on these topics, but due to various circumstances, only preliminary planning and literature search activities have been accomplished on these projects during the contract year covered by this report.

Simulated versus Live Fire for Helicopter Gunnery Training

Live fire training, especially with larger weapon systems, has become less feasible for two reasons. First, increased sophistication and lethality have greatly increased costs. Second, increased effective ranges of the weapons have made it more difficult to find firing ranges where they can be safely fired. As a result, for both cost and safety reasons, simulation instead of live firing has become quite attractive. Simulated fire has been explored as a substitute for live firing in many areas, and usually has been found to be an effective method of training, thereby making possible large monetary savings and increased safety in training activities.[1] However, the effectiveness of the simulator used for training COBRA-TOW gunners has not been determined.

Considering the high cost of the COBRA-TOW weapon system, it is important that gunners be trained to a high level of skill so that the

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[1] For example, see T. R. Powers, M. R. McCluskey, and D. F. Haggard. *Determination of the Contribution of Live Firing to Weapons Proficiency*, Final Report FR-DC(C)-75-1, Human Resources Research Organization, Alexandria, Virginia, March 1975.

weapon system may function at its maximum effectivenss. Thus, before simulated fire is widely adopted as a method for training COBRA-TOW gunners, its effectiveness must be evaluated. However, the high cost of the TOW rounds, which must be fired live to provide criterion measures for evaluating the effectiveness of simulated firings for training purposes, has made it necessary that research on this subject be conducted as a part of major TCATA tests. Unfortunately, TCATA tests that might have provided a means of carrying out this research have been delayed and finally cancelled. Therefore, at the time this report was written, nothing more could be written on this topic than the problem statement above.

Fatigue Effects of Night Vision Goggle Use

Night vision goggles (AN/PVS-5) have proven useful in making it possible for personnel to carry out a wide variety of activities at night without using any of the various kinds of illumination that would enable enemy forces to detect and locate them.[2,3,4,5,6] One of the most

[2] J. B. Jones. *Military Potential Test of Night Vision Goggles, AN/PVS-5*, Final Report, US Army Infantry School, Fort Benning, Georgia, August 1972.

[3] MASSTER Test No. 154. *User Evaluation, Night Vision Goggles AN/PVS-5, and 1X and 3X Pocketscopes*, Test Report, Headquarters, MASSTER, Fort Hood, Texas, January 1973.

[4] W. W. Atwood and J. G. East. *Night Aircraft Maintenance*, Test Report No. FM 285, Headquarters, MASSTER, Fort Hood, Texas, April 1975.

[5] M. G. Sanders, K. A. Kimball, T. L. Frezell, and M. A. Hofmann. *Aviator Performance Measurement During Low Altitude Rotary Wing Flight With the AN/PVS-5 Night Vision Goggles*, USAARL Report 76-10, US Army Aeromedical Research Laboratory, Fort Rucker, Alabama, December 1975.

[6] B. C. Amidon and C. G. Paulsen. *COBRA Day/Night Experiment*, MASSTER Test No. 1040, Headquarters, MASSTER, Fort Hood, Texas, March 1973.

demanding tasks for which the night vision goggles have been used has been flying helicopters at night, particularly Nap-of-the-Earth (NOE) flying. Complaints of severe fatigue effects in night helicopter operations using night vision goggles, particularly when flying night missions after extensive daylight operations, have stimulated the beginnings of research on the problem. All that has been accomplished to date has been a search of test reports and other literature for reports of fatigue, eyestrain, and muscle strain (from the unbalanced weight of the goggles on the head). A number of such reports have been found, in addition to the HRN submitted by the 6th US Cavalry Brigade (Air Combat), but no study designed specifically to investigate fatigue effects has been encountered.

The night vision goggles were not available in the 6th US Cavalry Brigade (Air Combat) until late February 1977. Therefore, work on this study was started very late in the contract year. It is planned to continue this work during the following contract year.

In MASSTER Test No. 154[7] the night vision goggles were used in a variety of helicopter flying tasks, including NOE flying, navigation, formation flying, confined area landings, hover maneuvers and takeoffs, station keeping, collision avoidance, target acquisition, and firing of 2.75 FFAR rockets. Generally, it was concluded that the night vision goggles give the helicopter pilot a night mission performance capability that is far superior to his capability with unaided vision. However, a number of problems in the area of fatigue were encountered. During flight maneuvers vertical "G" force loading was encountered, and because

[7]MASSTER Test No. 154, *op. cit.*, p 6.

nearly all of the weight of the night vision goggles (approximately 1.9 pounds) is on the front of the wearer's head, noticeable muscle strain was reported. Pilots expressed concern that in a very hard landing, the weight of the goggles on their heads would cause head twisting and possibly injury. Eyestrain was also reported. Flights of 30 to 45 minutes duration were found to be acceptable with continuous use of the goggles.

Sanders, Kimball, Frezell, and Hofmann[8] report on a project which used an instrumented helicopter to study pilot performance in a standard set of flight maneuvers, and in NOE flight. They report some nausea, headache, and vertigo, but nearly all of the pilots reported that they were more tense when wearing the night vision goggles than when flying with unaided vision. It was felt that the tension was due to (1) tunnel vision or restricted field-of-view, (2) poor depth perception, and (3) unfamiliarity or lack of confidence in the goggles. There were also reports of unequal weight and pressure distribution with the helmet-goggle system used (the night vision goggles were mounted on the SPH-4 helmet). All of these factors would contribute to general bodily fatigue. The six pilots who participated in this project estimated, on the average, that the maximum feasible length of mission using the night vision goggles would be 2 1/4 hours.

Wiley and Holley[9] report on a careful evaluation of the visual performance of the man-goggle system, using optometric methods and

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[8] Sanders, Kimball, Frezell, and Hofmann, *op. cit.*, particularly pp 38-39.

[9] R. W. Wiley and F. F. Holley. *Vision with the AN/PVS-5 Night Vision Goggles*, ARL-76-DA 1498, US Army Aeromedical Research Laboratory, Fort Rucker, Alabama, April 1976.

instruments. Studies were carried out in both laboratory and field settings. Wiley, Glick, Bucha, and Parks[10] also report specifically on depth perception with night vision goggles, using precise optometric methods and instruments. These studies do not deal with the fatigue problem, but they do provide good standards of objective visual performance (acuity and depth perception), so that research on fatigue effects of night vision goggle use can determine whether prolonged use (2.5 to 3 hours) of the goggles results in deterioration of these visual performances.

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[10] R. W. Wiley, D. D. Glick, C. T. Bucha, and C. K. Park. *Depth Perception with the AN/PVS-5 Night Vision Goggle*, US Army Aeromedical Research Laboratory, Fort Rucker, Alabama, July 1976.

TECHNICAL APPENDIX A

Order in Which Observers Viewed Targets at Each Scale Range: Preliminary Experiment

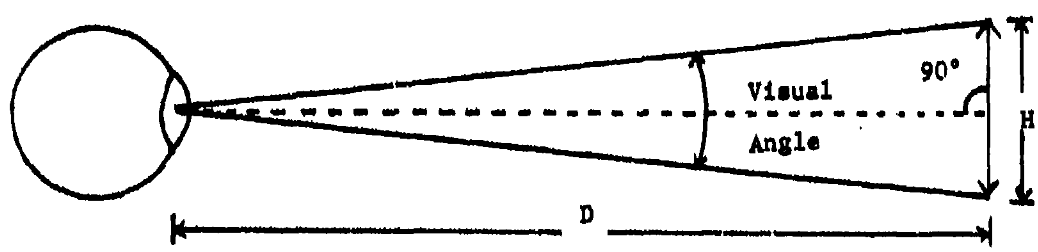
	Training		Testing	
Observer	3000 m	4000 m	3000 m	4000 m
1	1	2	2	1
2	2	1	1	2
3	1	2	2	1
4	2	1	1	2
5	1	2	2	1
6	2	1	1	2
7	1	2	2	1
8	2	1	1	2
9	1	2	2	1
10	2	1	1	2
11	1	2	2	1
12	2	1	1	2
13	1	2	2	1
14	2	1	1	2
15	1	2	2	1
16	2	1	1	2
17	1	2	2	1
18	2	1	1	2
19	1	2	1	2
20	2	1	1	2

TECHNICAL APPENDIX B

Derivation of the Range Adjustment Equation: Preliminary Experiment

Problem: To calculate reduced-scale distances such that when observers view 1/87 scale models using 7x50 binoculars, they will see visual images of the same size as if they were viewing full-scale targets at full-scale ranges using an XM65 gunsight adjusted to the 13X setting.

An observer views an object of dimension H perpendicularly at a distance D:



The visual angle, then, is 2 arctan (1/2 H/D).

Since we are concerned with very small visual angles (3 to 4 minutes), we set 2 arctan (1/2 H/D) = 1' and obtain the relationship between visual angle in minutes (VA), dimension of object viewed (H), and distance of object viewed D:

$$1' = 2 \arctan (1/2\ H/D)$$

$$30'' = \arctan (1/2\ H/D)$$

$$1/2\ H/D = \tan 30''$$

Therefore, we multiply (1/2 H/D) by the reciprocal of tan 30" so that:

$$VA = 1' = (1/\tan 30'') (1/2\ H/D)$$

$$= (1/(2 \tan 30'')) (H/D)$$

Assuming that the value of the tangent is a linear function of the angle in the vicinity of 1', we may use this relationship to compute the necessary reduced-scale distances.

If the object of dimension H is viewed with optical device A, with magnification M_1, the visual angle of the enlarged image will be $VA = M_1 (1/(2 \tan 30'')) (H/D)$.

Likewise, if the same object is viewed with optical device B, with magnification M_2, the visual angle of the enlarged image will be $VA = M_2 (1/(2 \tan 30'')) (H/D)$.

We wish to determine the distance, D', such that if the observer views the object of dimension H with optical device A, the visual angle will be the same as if he were viewing the object at distance D with optical device B. Therefore, we set the two visual angles equal:

$$(M/(2 \tan 30'')) (H/D') = M_2/(2 \tan 30'')) (H/D)$$

and solve for D':

$$M_1HD = M_2HD'$$

$$M_1D/M_2 = D'$$

Now, if the object to be viewed is a 1/R scale model, the reduced-scale distance from which it should be viewed so that the visual image is the same size as if the full-size object were viewed at distance D is D/R. Substituting D/R for D in the above relationship yields:

$$D' = (M_1D)/(M_2R).$$

Using this equation and setting $M_1 = 7$ (7x50 binoculars), $M_2 = 13$ (13X XM65 gunsight), and $R = 87$ (1/87 scale models); we calculate that the scale range, D', corresponding to a full-scale range of 3000 meters (D) is 18.57 meters (61 feet). Likewise, the scaled range corresponding to a full-scale range of 4000 meters is 24.76 meters (81 feet).

TECHNICAL APPENDIX C

Examples of Target Presentation Sequences for Training and Testing: Preliminary Experiment

Training				Testing			
3000 m		4000 m		3000 m		4000 m	
Trial	Target	Trial	Target	Trial	Target	Trial	Target
1	M60-OL	1	M113-SR	1	CH-OL	1	AMX-SL
2	ZSU 57-OL	2	T54-OL	2	PT 76-F	2	M60-SR
3	CH-OL	3	ZSU 57-SL	3	T54-OR	3	CH-OR
4	M113-OR	4	CH-OR	4	M113-OR	4	T54-OL
5	M60-SR	5	ZSU 57-OR	5	CH-SL	5	M60-OR
6	T54-F	6	M113-F	6	ZSU 57-OL	6	M113-F
7	M113-F	7	CH-F	7	AMX-OR	7	T54-F
8	ZSU 57-F	8	M60-F	8	M60-OL	8	ZSU 57-SR
9	T54-OR	9	CH-SL	9	T54-SL	9	M113-OL
10	CH-SL	10	M60-SL	10	M113-SR	10	ZSU 57-OR
11	T54-SR	11	M60-OR	11	AMX-SL	11	ZSU 57-F
12	CH-F	12	T54-F	12	ZSU 57-SR	12	T54-SR
13	M113-SL	13	T54-SR	13	PT 76-OL	13	PT 76-SL
14	ZSU 57-SR	14	M113-OL	14	PT 76-SR	14	AMX-OL
15	M60-F	15	ZSU 57-F	15	T54-F	15	M113-SL
				16	[illegible]	16	AMX-F
				17	ZSU 57-F	17	PT 76-OR
				18	M60-SR	18	CH-F
				19	AMX-F	19	CH-SL
				20	CH-F	20	M60-F
				21	M113-F	21	PT 76-F

TECHNICAL APPENDIX D

Analyses of Variance of Initial Target Recognition and Identification Performance: Preliminary Experiment

These analyses are two-factor mixed designs, with Range (2 levels) as a between-subjects factor and Vehicle Type (5 levels) as a within-subjects factor. It is recognized that data for these analyses were dichotomous (0 or 1). Some writers on statistics might consider such data not suitable for the analysis of variance technique, but Cochran* has indicated that treatment of such data as if the measurements were continuous, normally distributed variables will yield probability statements that are very similar to those obtained from analogous nonparametric techniques.

*W. G. Cochran. "The Comparison of Percentages in Matched Sample," *Biometrika*, 1950, 37, 256-266.

Analysis of Variance of Initial Target Recognition Performance:
Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	16	2.61		
Range (R)	1	.46	.46	3.28
Observer Within Group Error	15	2.15	.14	
Within Observers	68	16.80		
Vehicle Type (T)	4	2.70	.68	3.09*
R x T	4	1.15	.29	1.32
T x Observer Within Group Error	60	12.95	.22	
TOTAL	84	19.41		

*$p < .05$

Analysis of Variance of Initial Target Identification Performance: Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	16	3.95		
Range (R)	1	.17	.17	.68
Observer Within Group Error	15	3.78	.25	
Within Observers	68	16.00		
Vehicle Type (T)	4	2.77	.69	3.63*
R x T	4	1.69	.42	2.21
T x Observer Within Group Error	60	11.54	.19	
TOTAL	84	19.95		

*p <.05

TECHNICAL APPENDIX E

Analyses of Variance of Target Recognition and Identification Performance During Training Phase: Preliminary Experiment

These analyses are two-factor mixed designs, with Group (2 levels) as a between-subjects factor and Presentation Block (6 levels) as a within-subjects factor. The scores entered into these analyses were composite scores for presentation blocks, each consisting of five target presentations, and thus could vary from 0 to 5. The two groups of subjects were constituted in the following fashion: Group I consisted of the 10 observers to whom the first series of 15 target presentations was at 3000 meters simulated range and the second series of 15 target presentations was at 4000 meters simulated range. Group II consisted of the 10 observers to whom the two series of target presentations were made in the opposite order, i.e., 4000 meters first and 3000 meters second.

Analysis of Variance of Target Recognition Performance
During Training Phase: Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	14.0		
Groups (G)	1	2.7	2.70	4.29
Observer Within Group Error	18	11.3	.63	
Within Observers	100	90.5		
Presentation Block (P)	5	37.2	7.50	13.16***
G x P	5	2.2	.44	.77
P x Observer Within Group Error	90	51.1	.57	
TOTAL	119	104.5		

***p <.001

Analysis of Variance of Target Identification Performance
During Training Phase: Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	48.6		
Groups (G)	1	9.1	9.10	4.15
Observer Within Group Error	18	39.5	2.19	
Within Observers	100	190.5		
Presentation Block (P)	5	123.7	24.74	36.38***
G x P	5	5.7	1.14	1.68
P x Observer Within Group Error	90	61.1	.68	
TOTAL	119	239.1		

***p <.001

TECHNICAL APPENDIX F

Analyses of Variance of Posttraining Target Recognition and Identification Performance: Preliminary Experiment

These analyses are three-factor mixed designs, with Group (2 levels) as a between-subjects factor, and Range (2 levels) and Vehicle Type (5 levels) as within-subjects factors. The scores entered into these analyses were composite scores for three presentations of each type of vehicle at each of the two simulated ranges, and thus could range from 0 to 3. The two groups of subjects were constituted in the same fashion as those in the analyses of Technical Appendix E.

Analysis of Variance of Posttraining Target Recognition Performance:
Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	11.12		
Groups (G)	1	1.28	1.28	2.33
Observer Within Group Error	18	9.84	.55	
Within Observers	180	35.20		
Range (R)	1	.02	.02	.11
G x R	1	.02	.02	.11
R x Observer Within Group Error	18	3.16	.18	
Vehicle Type (T)	4	5.57	1.39	6.62***
G x T	4	1.87	.47	2.24
T x Observer Within Group Error	72	14.76	.21	
R x T	4	.53	.13	1.00
G x R x T	4	.03	.01	.08
R x T x Observer Within Group Error	72	9.24	.13	
TOTAL	199	46.32		

***$p < .001$

Analysis of Variance for Posttraining Target Identification Performance : Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
<u>Between Observers</u>	<u>19</u>	<u>19.48</u>		
Groups (G)	1	.98	.98	.95
Observer Within Group Error	18	18.50	1.03	
<u>Within Observers</u>	<u>180</u>	<u>65.40</u>		
Range (R)	1	.02	.02	.12
G x R	1	.08	.08	.50
R x Observer Within Group Error	18	2.90	.16	
Vehicle Type (T)	4	9.58	2.40	5.45***
G x T	4	1.12	.28	.64
T x Observer Within Group Error	72	31.70	.44	
R x T	4	1.08	.27	1.04
G x R x T	4	.22	.06	.23
R x T x Observer Within Group Error	72	18.70	.26	
TOTAL	199	84.88		

***p <.001

TECHNICAL APPENDIX G

Analyses of Variance of Target Recognition and Identification Performance on Two Additional, Unfamiliar Vehicles: Preliminary Experiment

These analyses are three-factor mixed designs, with Group (2 levels) as a between-subjects factor, and Range (2 levels) and Vehicle Type (2 levels) as within-subjects factors. The scores entered into these analyses were dichotomous scores (0 or 1). See footnote in Technical Appendix D. The two groups of subjects were constituted in the same fashion as those in the analyses of Technical Appendix E.

Analysis of Variance of Target Recognition Performance on
Two Additional, Unfamiliar Vehicles: Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	16	17.118		
Groups (G)	1	.687	.687	0.63
Observer Within Group Error	15	16.431	1.095	
Within Observers	51	89.750		
Range (R)	1	.133	.133	0.29
G x R	1	1.243	1.243	2.71
R x Observer Within Group Error	15	6.874	.458	
Vehicle Type (T)	1	58.368	58.368	47.19***
G x T	1	.327	.327	0.26
T x Observer Within Group Error	15	18.555	1.237	
R x T	1	.014	.014	0.06
G x R x T	1	.735	.735	3.15
R x T x Observer Within Group Error	15	3.501	.233	
TOTAL	67	106.868		

***$p < .001$

Analysis of Variance of Target Identification Performance on Two Additional, Unfamiliar Vehicles: Preliminary Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	16	24.765		
Groups (G)	1	.001	.001	0.00
Observer Within Group Error	15	24.764	1.651	
Within Observers	51	52.000		
Range (R)	1	.236	.236	1.41
G x R	1	.264	.264	1.58
R x Observer Within Group Error	15	2.500	.167	
Vehicle Type (T)	1	19.059	19.059	10.63**
G x T	1	.052	.052	0.03
T x Observer Within Group Error	15	26.889	1.793	
R x T	1	.058	.058	0.30
G x R x T	1	.067	.067	0.35
R x T x Observer Within Group Error	15	2.875	.192	
TOTAL	67	76.765		

**$p < .01$

TECHNICAL APPENDIX H

Example of Target Presentation Order: Main Experiment

Trial	Target	Response	Trial	Target	Response
1	M60-OL	_____	16	M113-OR	_____
2	ZSU 57-OR	_____	17	T54-SL	_____
3	CH-SL	_____	18	M60-SR	_____
4	M113-SR	_____	19	ZSU 57-F	_____
5	T54-F	_____	20	CH-OL	_____
6	ZSU 57-SL	_____	21	T54-SR	_____
7	CH-SR	_____	22	M60-F	_____
8	M113-F	_____	23	ZSU 57-OL	_____
9	T54-OL	_____	24	CH-OR	_____
10	M60-OR	_____	25	M113-SL	_____
11	CH-F	_____			
12	M113-OL	_____			
13	T54-OR	_____			
14	M60-SL	_____			
15	ZSU 57-SR	_____			

TECHNICAL APPENDIX I

Analyses of Variance of Target Recognition and Identification Performance During Pretraining Phase: Main Experiment

These analyses are three-factor mixed designs, with Range (2 levels) as a between subjects factor; and Vehicle Type (5 levels) and Target View (5 levels) as within-subjects factors. The scores entered into these analyses were dichotomous scores (0 or 1). See footnote in Technical Appendix D.

Analysis of Variance of Target Recognition Performance
During Pretraining Phase: Main Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	7.078		
Range (R)	1	1.250	1.250	3.86
Observer Within Group Error	18	5.828	.324	
Within Observers	480	53.840		
Vehicle Type (T)	4	2.368	.592	2.32
R x T	4	1.120	.280	1.10
T x Observer Within Group Error	72	18.352	.255	
Target View (V)	4	2.548	.637	6.85***
R x V	4	.180	.045	.48
V x Observer Within Group Error	72	6.712	.093	
T x V	16	2.052	.128	1.86
R x T x V	16	.500	.031	.45
T x V x Observer Within Group Error	288	20.008	.069	
TOTAL	499	60.918		

***$p < .001$

Analysis of Variance of Target Identification Performance
During Pretraining Phase: Main Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	30.008		
Range (R)	1	4.608	4.608	3.27
Observer Within Group Error	18	25.400	1.411	
Within Observers	480	88.720		
Vehicle Type (T)	4	4.688	1.172	2.02
R x T	4	1.432	.358	.62
T x Observer Within Group Error	72	41.800	.581	
Target View (V)	4	1.428	.357	2.90*
R x V	4	.052	.013	.11
V x Observer Within Group Error	72	8.840	.123	
T x V	16	.312	.020	.20
R x T x V	16	.808	.050	.49
T x V x Observer Within Group Error	288	29.360	.102	
TOTAL	499	118.728		

*p <.05

TECHNICAL APPENDIX J

Analyses of Variance of Pretraining Target Recognition and Identification Performance for Evidence of Learning: Main Experiment

These analyses are two-factor mixed analyses, with Range (2 levels) as a between-subjects factor, and target Presentation Number (25 levels) as a within-subjects factor. The scores entered into these analyses were dichotomous (0 or 1). See footnote in Technical Appendix D.

Analysis of Variance of Pretraining Target Recognition
Performance for Evidence of Learning: Main Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	7.078		
Range (R)	1	1.250	1.250	3.86
Observer Within Group Error	18	5.828	.324	
Within Observers	480	53.840		
Presentation Number (N)	24	4.168	.174	1.64*
R x N	24	3.800	.158	1.49
N x Observer Within Group Error	432	45.872	.106	
TOTAL	499	60.198		

*p <.05

Analysis of Variance of Pretraining Target Identification Performance for Evidence of Learning: Main Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	30.008		
Range (R)	1	4.608	4.608	3.27
Observer Within Group Error	18	25.400	1.411	
Within Observers	480	88.720		
Presentation Number (N)	24	5.028	.210	1.14
R x N	24	3.692	.154	0.83
N x Observer Within Group Error	432	80.000	.185	
TOTAL	499	118.728		

TECHNICAL APPENDIX K

Analyses of Variance of Target Recognition and Identification Performance on Two Additional, Unfamiliar Vehicles: Main Experiment

The main analyses in this appendix are three-factor mixed designs, with Range (2 levels) and Order (2 levels) as between-subjects factors, and Vehicle Type (2 levels) as a within-subjects factor. The scores entered into these analyses were dichotomous scores (0 or 1). See footnote in Technical Appendix D. The two levels on the Order factor were: observer was shown the AMX 30 tank first and the PT 76 ARV second; observer was shown the PT 76 ARV first and the AMX 30 tank second.

The Range by Order interaction ($p < .05$) in the analysis of target recognition performance may be examined in the table below.

Percent Correct Recognition

	ORDER		
	AMX - PT 76	PT 76 - AMX	TOTAL
TARGET RANGE			
3000 meters	60	80	70
4000 meters	80	90	85
TOTAL	70	85	77.5

The source of this interaction is apparently the low recognition rate (60%) when the AMX 30 tank was presented to the observer first at a scaled range of 3000 meters. No reasonable explanation has been found for this interaction, and it is probably a Type 1 error.

Analysis of Variance of Target Recognition Performance
on Two Additional, Unfamiliar Vehicles: Main Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	2.475		
Range (R)	1	.225	.225	2.32
Order (O)	1	.225	.225	2.32
R x O	1	.475	.475	4.90*
Observer Within Group Error	16	1.550	.097	
Within Observers	20	4.500		
Vehicle Type (T)	1	.625	.625	3.08
T x R	1	.225	.225	1.11
T x O	1	.225	.225	1.11
T x R x O	1	.175	.175	.86
T x Observer Within Group Error	16	3.250	.203	
TOTAL	39	6.975		

*p <.05

Analysis of Variance of Target Identification Performance on Two Additional, Unfamiliar Vehicles: Main Experiment

SOURCE OF VARIATION	DF	SS	MS	F
Between Observers	19	4.875		
Range (R)	1	.025	.025	.09
Order (O)	1	.225	.225	.83
R x O	1	.275	.275	1.01
Observer Within Group Error	16	4.350	.272	
Within Observers	20	4.500		
Vehicle Type (T)	1	2.025	2.025	16.20***
T x R	1	.025	.025	.20
T x O	1	.225	.225	1.80
T x R x O	1	.225	.225	1.80
T x Observer Within Group Error	16	2.000	.125	
TOTAL	39	9.375		

***p <.001

Analysis of the Effects of Target View on the Recognition and Identification of the AMX 30 Tank and the PT 76 ARV: Main Experiment

RECOGNITION

	AMX 30				PT 76			
SOURCE OF VARIATION	DF	SS	MS	F	DF	SS	MS	F
Between (Target View)	4	.80	.20	.80	4	.80	.20	3.00
Within (Error)	15	3.75	.25		15	1.00	.067	
TOTAL	19	4.55			19	1.80		

IDENTIFICATION

	AMX 30				PT 76			
SOURCE OF VARIATION	DF	SS	MS	F	DF	SS	MS	F
Between (Target View)	4	.80	.20	1.67	4	1.30	.32	1.39
Within (Error)	15	1.75	.12		15	3.50	.23	
TOTAL	19	2.55			19	4.80		

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